THE EFFECTS OF THE ALLOCATION OF ATTENTION CONGRUENT WITH LATERALIZED COGNITIVE TASKS ON EEG COHERENCE MEASUREMENTS

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The single task condition of the Urbanczyk and Kennelly (1991) study was conducted while recording a continuous electroencephalographic (EEG) record. Attention was allocated by instructed lateral head orienting and eye gaze either congruently or incongruently with lateralized cognitive tasks. Thirty university subjects retained a digit span or a spatial location span for a 20 second retention interval. EEG data were extracted from the 20 second retention intervals and interhemispheric coherence was calculated for homologous sites in the temporal, parietal and occipital regions of the brain. There was a main effect for group, with congruent orienting producing greater coherence values than incongruent orienting. This effect of attention on alpha coherence values was found in the low alpha (8-10 Hz) frequency band. This provides evidence that the lower alpha frequency band is reflective of manipulations of attention. The higher coherence measures for the congruent orienting group indicates that homologous regions of the two hemispheres are more coupled into a single system when lateralized attention activates the same hemisphere performing the cognitive task. In the higher alpha frequency band (11-13 Hz) group, sex, site and task interacted. This provides evidence that the higher alpha band is more affected by cognitive processing of the specific task undertaken. An interhemispheric brain system, affected by the lateral orientation of attention, may underlie psychometric intelligence's general "g" ability (Spearman, 1927.)

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CHAPTER 1

Introduction

Electroencephalographic (EEG) coherence between pairs of scalp electrode locations can provide an estimate of the functional relationship between specific brain regions (Shaw, 1981). The coherence function gives information similar to that of a correlation, but shows the covariation between two signals in the frequency domain rather than the time domain (Shaw, 1981). The EEG signal represents a series of voltage and time values, and thus, can be considered as a multivariate time series belonging to a category of stochastic processes. The coherence function is a statistical measure used to determine the likelihood of two stochastic signals arising from some common generator process, and the frequency bands in which this occurs. Coherence between two EEG signals differentiates spontaneous rhythms from functionally related rhythms. The present study uses EEG coherence measures between homologous sites in each of the cerebral hemispheres to examine the degree to which the left and right hemispheres function together under several conditions of attentional allocation. The interest in the effect of manipulations of attention on EEG interhemispheric coherence arises from the evidence that attention may be the general brain system underlying the general ability or "g" represented in psychometric measures of human intelligence.

This paper will review the literature related to attention and the general ability or "g" in human intelligence. Then the relationship of attention and hemispheric interaction will be discussed. Next the topics of attention as it relates to sex differences and the

corpus callosum, sex differences and EEG measures of hemispheric activation, attention and EEG measures, and the present study will be addressed in turn.

Attention and the general ability "g" in human intelligence.

Psychometric measurements of general intelligence such as the Wechsler tests and the Stanford-Binet include many different types of items, including verbal and nonverbal. Performance on a general intelligence test is scored to yield several sub-scores as well as an overall score. Although individuals rarely perform equally well on all the different kinds of items included in an intelligence test, subtests measuring different abilities are always positively correlated if samples are large enough and heterogeneous enough (Humphreys, 1981). People who score high on one such subtest are likely to score relatively high on other different tests as well.

Charles Spearman (1927) was the first to observe that cognitive task performances were positively correlated and offer a theoretical explanation of this phenomenon. Spearman conducted a series of factor analytic studies and showed that some portion of the variance of scores on each test can be mathematically attributed to a general factor. Thus, he interpreted his finding of the positive correlation between cognitive tasks as due to a general ability or "g". Spearman likened "g" to a kind of mental energy (1927).

Although the positive correlation of cognitive task performances is a robust phenomenon (Humphreys, 1981) there is no full agreement on exactly what "g" represents. G. Thomson (1938) challenged Spearman's view and suggested that this robust phenomenon was due to the overlapping of multiple specific abilities necessary to

any two cognitive performances and found a general ability unnecessary to the explanation of the phenomenon. More recently, "g" has been described as a generalized abstract reasoning ability (Gustafsson, 1984) or an index measure of neural processing speed (Reed & Jensen, 1992). The most widely accepted current view of intelligence measures envisages a hierarchical model of cognitive abilities which places a general intelligence factor "g" at the apex and various more specialized abilities arrayed below it (Neisser, Boodoo, Bouchard, Boykin, Brody, Ceci, Halpern, Lowhlin, Perloff, Sternburg, & Urbina, 1996.)

Several researchers, notably Earle Hunt and Lazar Stankov, adopted Spearman's hypothesis that "g" might be indicative of a general ability "g" and further suggested attention as the candidate for "g". Stankov (1978, 1979) and Hunt (1980) suggested that the tendency for cognitive tasks to be positively correlated could best be examined under attention demanding situations, in particular, with the use of the dual task or split attention experimental paradigm. This experimental paradigm requires subjects to perform two tasks at the same time and was used to test the hypothesis that "g" is, or is related to, attention.

In a series of dichotic listening tests administered under both single task and dual task conditions, Stankov (Fogarty & Stankov, 1982; Stankov, 1983a) discovered a substantial rise in the correlations between two auditory tasks when going from the single task condition to the competing or dual task condition. This led Stankov to conclude that attention and intelligence are related concepts with both being defined in terms of coping with a large amount of information (1983b). The correlations between cognitive tasks

increased from the single to the dual task situation in Stankov's studies, as well as in the studies of Hunt (1980) who used different tasks. Therefore, there was empirical evidence linking intelligence with different phenomena considered to be attentional regardless of the particular tasks employed or the particular language attached to the definition of attention i.e. visual search, vigilance, limited resources, etc. In effect, the definition of attention becomes procedural. The dual task, i.e. attention demanding condition, affects not only the capacity of performance but also affects evidence that dissimilar tasks are supported by a common ability or overlapping specific abilities.

Attention and hemispheric interaction.

The psychological conditions under which the hemispheres tackle cognitive tasks bilaterally (coupled) versus. unilaterally (decoupled) have been the subject of considerable research. Although the hemispheres are thought to be specialized for particular cognitive tasks both hemispheres can and do support most cognitive processing (Hellige, 1993). In the psychological literature the circumstances under which the hemispheres shift from an unintegrated, i.e. decoupled, type of processing to a more integrated, i.e. coupled type of processing is slowly emerging. Hemispheric specialization is by no means absolute and can generally be considered as a continuum of differences between the hemispheres in competency for any given task and can be assessed by measures such as speed and accuracy. In general, it is indicated in the psychological literature that bilateral processing is advantageous under conditions of task complexity (with complexity including attention demanding tasks) (Belger & Banich, 1998) or memory load (Berryman & Kennelly 1992). This hemispheric coupling appears

to occur more readily for right handed females than for right handed males especially under dual task situations involving a memory load (Berryman & Kennelly, 1992).

A series of behavioral studies (Urbanczyk, Angel, & Kennelly, 1988; Urbanczyk & Kennelly, 1991) demonstrated that cognitive tasks lateralized to opposite hemispheres become more positively correlated if performed with a congruent orientation of attention. Specifically, the correlations between the performance measure of retention accuracy of a left hemisphere digit span memory task and a right hemisphere spatial span memory task increased when the balance of attention was shifted laterally toward the hemisphere which performed each task. The proportion of significant positive correlations between the tasks lateralized to opposite hemispheres was also found to be higher for females than for males regardless of the orientation of attention (Urbanczyk & Kennelly 1991; Berryman & Kennelly 1992). However, sex differences in such correlations were not found in two prior related experiments (Urbanczyk, Angel & Kennelly, 1988). Because the significance of positive correlations between cognitive task performances varied systematically and predictably with the lateralization of attention, it has been offered as the empirical basis for associating the cortical activation component of attention with Spearman's general ability "g" (1927) in human intelligence (Stankov, 1978, 1979).

Urbanczyk, Angel and Kennelly (1988) hypothesized that if the single vs. dual task manipulation affects the size of the correlations between dissimilar cognitive tasks as Hunt and Stankov contended, then perhaps other manipulations of attention would affect the degree of correlations between cognitive task performances. To test this hypothesis

Urbanczyk et al. (1988) applied Kinsbourne's model of attention to the dual task situation.

Kinsbourne's model of attention (1973) is one of cortical activation across cerebral space. This theory attempts to define the construct of attention in terms of its effect on the organization of cortical activation, i.e. through attention there is an allocation of functional cerebral space. Kinsbourne's theory is an alternative to the limited resource theory (Kahnemann, 1973), and proposes that each individual possesses a finite amount of functional cerebral space rather than possessing limited resources of mental effort or energy. The extent to which an individual is limited in cognitive processing depends upon the functional organization of the cerebral control centers relevant to the task or tasks at hand.

According to Kinsbourne the orientation of attention is directed by attentional control centers located in both the left and right hemispheres. At any particular time, the direction of attention across sensory space is determined by the distribution of activation across these orienting centers and across the hemispheres in general. When hemispheric activity is in exact balance, attention is centered. When hemispheric activation is asymmetric, as brought about by lateralized psychomotor and/or cognitive activity, the attentional gradient swings toward the more activated hemisphere and the contralateral side of space.

Kinsbourne's attentional model is expounded upon with the Kinsbourne and Hicks' (1978) functional cerebral distance principle. According to this principle, each behavior has a pattern of neuronal activity that is carried out in a certain locus of cerebral

space (1981). Because the brain is a highly linked neural network, the programming of a particular cognitive or psychomotor activity involves not only one specific controlling area, but also, by spread of activation, a larger proportion of functional cerebral space. This principal suggests if two tasks are lateralized to the same hemisphere the spread or overflow of activation to or from the homolateral attentional control center should be greater than to the contralateral attentional control center. This should produce an asymmetry of attentional activation and attention should shift to the more activated hemisphere and the contralateral side of space. If the tasks are lateralized to opposite hemispheres both hemispheres should show attentional activation resulting in a decreased asymmetry of activation. This spread of activation can be facilitating or interfering, depending on the demands of the cognitive task or tasks involved.

Applying Kinsbourne's model of attention to a dual task situation, Urbanczyk et al. (1988) selected individual tasks for the dual task paradigm, each of which would be a direct source of hemispheric activation, and therefore, each task would affect the balance of attentional orientation. It was hypothesized that if attention is a dynamic system underlying such task performances the difference in the size of the intercorrelations between the cognitive tasks would depend upon whether the gradient of attention was biased toward or away from the hemisphere performing the lateralized cognitive tasks. Unimanual key tapping served as the primary task and the short- term retention (20 sec.) of a digit span or visual-spatial span was the task given secondary emphasis. Sequence retention was performed either alone (the single task condition) or during finger tapping

(the dual task condition). In the dual task condition, finger tapping and the concurrent cognitive task were lateralized either to the same hemisphere or to different hemispheres.

In the first experiment the highest task intercorrelations between the digit task and the spatial task were found in the dual task condition where both the tapping task and the cognitive task were lateralized to the same hemisphere. The second highest task intercorrelations were found in the dual task situation where the tapping task and the cognitive task were lateralized to different hemispheres. The lowest correlations were found in the single task situation. Therefore, the first experiment in Urbanczyk et al. supports Stankov's hypothesis and extends it to suggest that the finding of higher correlations between cognitive tasks in the more attention demanding dual task situation depends on the hemispheric lateralization of the tasks involved. Kinsbourne's attentional model and functional cerebral distance principal suggest that the mechanisms underlying this effect are hemispheric activation and orientation of attention. Individual differences in attention appear to have the most powerful impact, producing the highest intercorrelations among the retention tasks, when attention is most consistently oriented to the hemisphere retaining the sequences.

In addition to the shifts in attention produced by lateralized psychomotor and cognitive tasks, Kinsbourne's model assumes that more overt lateral orienting behaviors such as spontaneous lateral eye movements and head turning reflect shifts in the gradient of attention as well. The second experiment in Urbanczyk et al. (1988) concerns itself with lateral shifts in gaze brought about by the dual task conditions. This experiment used the same design as the first experiment with the addition that a concealed video

camera was utilized to monitor and record eye movements and gaze direction during the 20 second tapping and retention intervals. Additionally the subject's tapping hand was screened from view. Lempert and Kinsbourne (1985) propose that less conflict between finger tapping and other activities occurs if the subjects tap without visual guidance. The subjects were scored on the number of seconds they looked left, right, up and centrally during the 20 second tapping and retention intervals. The results of the second experiment of Urbanczyk et al. produced the hypothesized results. In the dual task condition, unimanual finger tapping concurrent with sequence retention strongly and significantly lateralized gaze direction. Left hand tapping produced significantly more leftward looking relative to right hand tapping, and right hand tapping significantly increases rightward looking relative to left hand tapping.

Because the lateral gaze in Urbanczyk et. al (1988) was not instructed, and therefore not perfectly consistent, Urbanczyk and Kennelly (1991) decided to combine a voluntary lateral orientation of attention with the single and dual task conditions of the Urbanczyk et. al (1988) studies. The hemisphere congruent with or incongruent with each lateralized retention task was activated by instructing subjects to turn their heads and eyes to one side and maintain this orientation during the 20 second retention and tapping interval of each trial. Congruent or incongruent orientation was defined in terms of the sequence retained on that trial. Congruent orienting was rightward for digit sequences and leftward for visual spatial sequences. Incongruent orienting was leftward for digit sequences and rightward for visual spatial sequences. It was hypothesized that congruent orienting of attention with the retention tasks would produce higher positive

correlations between digit and spatial location tasks relative to incongruent orienting. Dual task conditions were expected to produce higher correlations between the retention tasks than the single task.

The results of Urbanczyk and Kennelly (1991) with regard to sex differences were somewhat surprising to them. Urbanczyk et al. (1988) found no sex differences. Urbanczyk and Kennelly (1991) expected to see the same pattern as was seen in the previous work. However, the pattern of the highest correlations being in the same hemisphere dual task condition, followed by the different hemisphere dual task condition, and then the single task condition was found only for females in the congruent orienting group. For males the highest intercorrelations were found in the different hemisphere dual task condition of the congruent orienting group. For both males and females orienting in a direction hemispherically congruent with the concurrent memory task significantly enhanced the proportion of positive correlations between digit and spatial retention task performances relative to incongruent orienting. There was also an effect of sex independent of orientation. Females demonstrated a higher proportion of positive correlations between the digit and spatial retention tasks than males did. The pattern of significant positive correlations between the digit span and the spatial span tasks are presented in Fig. 1.

As hypothesized, Urbanczyk and Kennelly (1991) demonstrated that congruent orientation of gaze enhanced the size and significance of positive correlations between digit and spatial location retention tasks relative to incongruent orientation. The orientation of gaze together with lateralized cognitive and psychomotor tasks produced

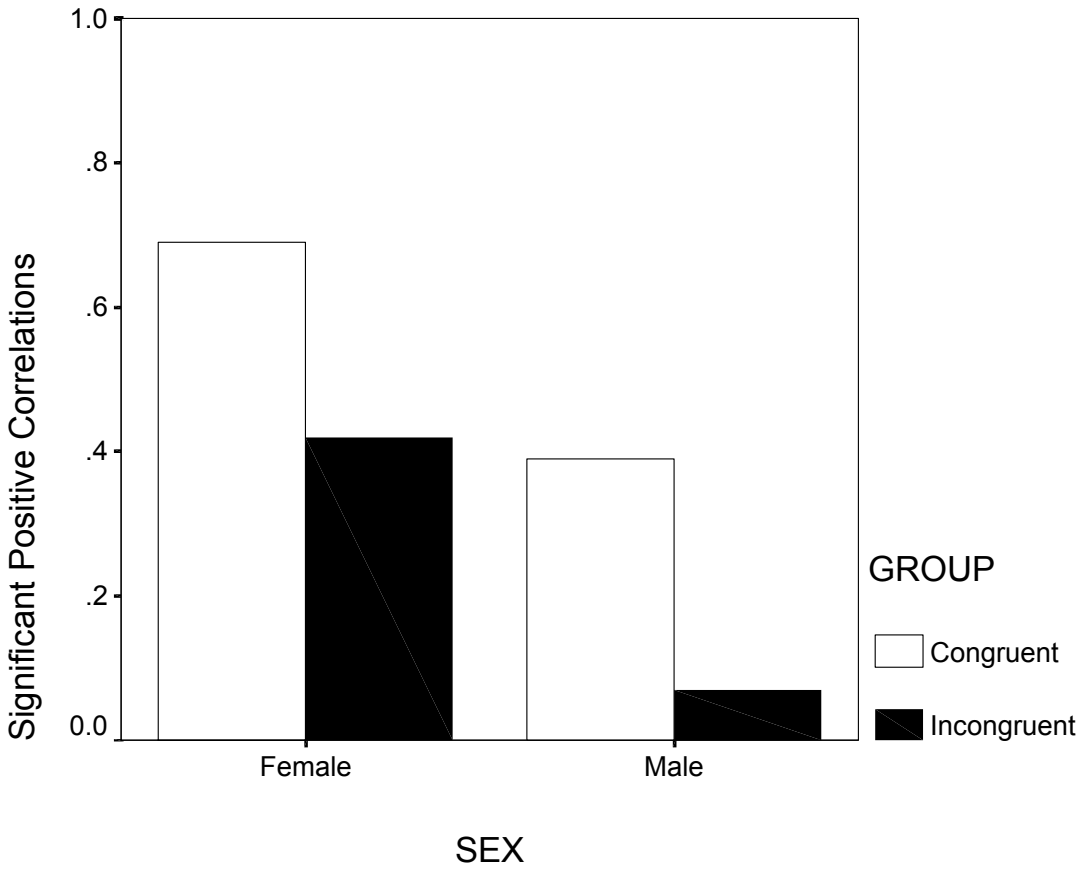


Fig. 1. The proportion of positive significant correlations between the digit span tasks and the spatial span tasks for females and males as reported in Urbanczyk and Kennelly, 1991.

an asymmetry of activation favoring the left hemisphere during digit sequence retention and favoring the right hemisphere during spatial location sequence retention. These findings together with those of Urbanczyk et al. (1988) strengthened the identification of positive correlations between lateralized cognitive tasks and Spearman's "g" with the cortical activation component of attention. Cognitive tasks lateralized to opposite hemispheres appear to become more dependent on a common cognitive resource, ability, or system when the left hemisphere is the more activated hemisphere for left hemisphere tasks and the right hemisphere is the more activated for right hemisphere tasks. Urbanczyk and Kennelly (1991) suggest that the consistent lateral orientation of attention congruent with the cognitive task may serve to integrate regions of the less activated hemisphere into networks of the more activated hemisphere, effectively producing a coupling effect while incongruent orientation of attention produces a decoupling effect.

Using a shape recognition paradigm, Kinsbourne and Byrd (1985) provided evidence that left hemisphere-right visual field and right hemisphere and left visual field performances are not supported by independent hemispheric resources under conditions of a verbal memory load. Under zero load conditions the correlations between the right visual field and the left visual field performances were not significantly different from zero. This lack of correlations between the performance of the two hemispheres indicates that the hemispheres are functioning independently of each other under relatively low load conditions. However, as the verbal memory load increased, there was a linear increase in the correlations between left hemisphere-right visual field and right

hemisphere-left visual field performances. Therefore, as memory load increased the left and right hemispheres depended upon something in common.

Evidence of a coupling effect between the two hemispheres was found in Berryman and Kennelly (1992), who conducted a visual field and reaction time study focusing on changes in interhemispheric correlations as a function of memory load or task complexity. This study used a left hemisphere-right visual field advantage task (LH-RVF) and a right hemisphere-left visual field advantage task (RH-LVF) for right-handed subjects under both single and dual task conditions. For the dual task, subjects held three or six consonant letters in memory while performing the visual field task (an even or odd number choice presented to respective visual fields as either a bar graph or word form).

Berryman and Kennelly (1992) found that RVF-LH and LVF-RH correlations increased for both of their visual field tasks systematically as a function of memory load. Also, as Urbanczyk and Kennelly (1991) had found, this study obtained sex differences with respect to these interhemispheric correlations. Females had many more significant correlations between both their visual field reaction tasks and the letter load retention task than did males. This provides additional behavioral evidence that dual task performances for females are supported to a greater degree by the same system, ability or resource than these performances are for males. Viewed within the context of Denenburg's model, as load increases, areas of the left and right hemispheres became increasingly coupled into a general system in support of lateralized task performances.

Denenburg's (1980) general systems model of brain organization provides a means for examining whether areas in the two hemispheres of the brain are working as a single integrated or coupled system. This model suggests that positive correlations between elements of a potential system indicate that the elements are coupled into a general system. For this model the left and right hemispheres would be the elements of a general brain system. When there is an absence of positive correlations between the elements pertaining to the hemispheres the brain system would appear to be functioning in a decoupled fashion and when there is a presence of positive correlations between the elements pertaining to the hemispheres the brain system would appear to be functioning in a coupled fashion. Denenburg's general systems model provides a theoretical basis for interpreting correlations between measures from the two hemispheres in terms of functional brain coupling into a general system.

In a theoretical article, Banich (1998) reviews a body of research from her laboratory indicating that a dispersal of processing across the cerebral hemispheres aids performance as task complexity increases. This evidence of hemispheric interaction, or coupling, under conditions of complexity holds across visual, auditory, and tactile modalities. Initially, Banich defined "increasing complexity" as increasing the number of computational steps that must occur for a task to be performed correctly. She later reformulated the notion of complexity to include situations which increase perceptual processing and/or comparison processing. These later studies encompass situations with increased attentional demands due to the inclusion of distracting information. These later studies replicated her earlier results demonstrating that interhemispheric interaction aids

performance regardless of whether the increased demands are by nature of the decision process or by the perceptual demands and/or comparison processes required by the task.

Banich proposes that interhemispheric interaction is the missing link in discussions of attentional processing. Based upon her results, Banich (1998) suggests that it is an increase in attentional demands which precipitates the advantage of interhemispheric interaction or coupling, indicating that the more attention a task demands, the more likely it is that an interaction or coupling of the hemispheres will be beneficial. Because her results consistently yield superior performance on cross-hemisphere trials as compared to within-hemisphere trials, Banich proposes that interhemispheric interaction is a means for modulating the attentional capacity of the brain. This view is consistent with the early writings of Kinsbourne and serves to integrate his ideas (Liederman, 1998). Similar to Kinsbourne, Banich does not appear to subscribe to a particular conceptualization or definition of attention. Banich makes the point that "central to most all of them (definitions of attention) is the cognitive mechanism that allows us to select information in some manner—ranging from selecting particular information from the vast stream of incoming sensory information to selection of a response from among a wide variety of output options" (p.130).

Attention and sex differences with respect to the corpus callosum.

It is assumed that this interaction between the hemispheres, which affects attentional processing occurs via the corpus callosum. Support for the mediation of attentional processing by the corpus callosum is gained from research on split-brain patients. Split-brain patients differ from neurologically intact patients in a number of

ways related to attentional processes including the ability for sustained attention and during dual task performance. Split-brain patients have difficulty sustaining attention for long periods of time, especially on tasks requiring mental concentration (Diamond, 1976, 1979). Although there is some conflicting evidence (Holtzman & Gazzaniga, 1985), the majority of evidence indicates that split-brain patients exhibit a decrement in performance compared to neurologically intact subjects under dual task conditions (Holtzman & Gazzaniga, 1982; Kreuter, Kinsbourne, & Trevarthen, 1972; Teng & Sperry, 1973, 1974). These decrements are not seen under single task conditions, suggesting that the dual task decrement is not attributable to difficulty of the patients to perform either of the single tasks. Commissurotomy patients have also demonstrated more severe decrements than neurologically intact subjects during dual task performance when the two tasks relied on the same hemisphere (Kreuter, Kinsbourne, & Trevarthen, 1972); this became increasingly evident as complexity increased, raising the possibility that the corpus callosum normally serves as a mechanism for uniting or coupling the hemispheres in pursuit of complex cognitive task performance.

In a rather substantial body of literature it has been suggested that measures of cerebral interhemispheric connectivity, namely corpus callosum size, are related to functional hemispheric asymmetries (Aboitiz, Scheibel & Zaidel, 1992; Clarke & Zaidel, 1994; Hines, Chiu, McAdams, Bentler & Lipcamon, 1992; O'Kusky et al., 1998; Zaidel, Aboitiz, & Clarke, 1995). These functional and anatomical asymmetries have been shown to be greater for right-handers than left-handers and greater in males compared to females. Although not without controversy (Bishop and Wahlster, 1998) the morphology

of the corpus callosum has been reported to show both handedness and sex differences. Witelson (1989) found that non-right handed subjects, referred to as mixed-handed subjects, had a larger total corpus callosum than consistent right-handers, with the greatest difference occurring in the isthmus. This effect of handedness occurred in men but not in women. Further, all women, regardless of hand preference had a larger absolute as well as relative isthmal area compared with the majority of men. Steinmetz, et al. (1992) failed to replicate Witelson's hand difference in corpus callosum anatomy but did confirm her finding of a larger proportional isthmus area in women irrespective of handedness. These findings support the contention of an increased connectivity of posterior brain regions in women. The isthmus of the corpus callosum interconnects the left and right temporal-parietal-occipital association cortex of the two hemispheres (deLacoste, Kirpatrick & Ross, 1985).

Despite many years of clinical research concerned with hemisphere damaged patients and commissurotomy patients the role of the corpus callosum in higher cognitive processing is still not clearly understood. Both excitatory models and inhibitory models have been proposed with respect to the functions of the corpus callosum in higher cognitive functions. Inhibitory models suggest that the corpus callosum transmits inihibition, i.e. when one hemisphere engages in a task for which it is specialized, it concurrently inhibits the other hemisphere (Chiarello and Maxfield, 1996; Clarke and Zaidel, 1994). This inhibition is thought to occur when one hemisphere is exclusively specialized for the task, both hemispheres simultaneously receive stimulus inputs and each proceeds to process them, or the non-specialized hemisphere impedes processing by

the specialized hemisphere. Excitatory models suggest that the corpus callosum transmits excitation, thereby spreading activation from the specialized hemisphere to the other hemisphere. This cross-collasal excitation may serve to enlarge the amount of cortex that is available for neural computation (Yazgan, Wexler, Kinsbourne, Peterson, and Leckman, 1995) and thereby subserves the role of attention to integrate regions of a less activated hemisphere during complex or attention demanding cognitive task performance.

As the principal means of interhemispheric communication, the corpus callosum contains millions of nerve fibers interconnecting the two cerebral hemispheres. The corpus callosum contains both larger diameter fibers, thought to mediate sensory-motor coordination, and smaller diameter fibers, which connect association areas (Aboitiz, Scheibel, Fisher and Zaidel, 1992). Normal variation in corpus callosum area has been shown to be more strongly correlated with small-diameter fibers indicating that behavioral laterality asymmetries may be related to cognitive/association functions rather than to the interhemispheric transfer of sensory information (Clarke, McCann, and Zaidel, 1997). Using MRI scans Yazgan, et al. (1995) examined the correlation of corpus callosum area with behavioral laterality as measured by dichotic word listening, line bisection and turning bias tests. They found that normal behavioral laterality increased as the corpus callosum became smaller. The authors interpreted their findings by suggesting that as one side of the brain assumes control of the behavior in these tasks, a smaller corpus callosum favors increasing control by the specialized hemisphere, whereas a larger corpus callosum distributes control more equitably between the two hemispheres. Recent functional neuroimaging studies support the view that cognitive

functions are not only underlain by specialized unilateral areas but also extensive additional areas in both hemispheres. A larger corpus callosum may favor a larger and better integrated system by facilitating recruitment of addition neural networks in the less specialized hemisphere (Yazgan et al. 1995).

Sex differences in laterality and EEG measures of hemispheric activation.

Although not conclusive (see Zaidel et al,1995), there is a considerable literature indicating sex differences in the degree of lateralization between the hemispheres for different cognitive functions (Halpern, 2000; Kimura, 1999). Voyer's (1996) meta-analysis examined 396 significance levels from a variety of studies on functional asymmetries within the auditory, visual, and tactile modalities using both verbal and nonverbal stimuli. He concluded that both laterality effects alone and sex differences in laterality are highly significant, particularly when verbal tasks are used in the visual and auditory modalities. This sex difference extends to the tactile modality when a one-tailed test of significance is used. The positive effect sizes indicate men to be more lateralized than women, i.e. males are more likely to separate information processing with both hemispheres working independently while females are more bilaterally organized with more common processing between the hemispheres.

One area where the most consistent sex differences in cognitive ability has been found, is in spatial ability, particularily involving tasks which require the formation of mental images and their rotation. Gill and O'Boyle (1997) monitored male and female performance on four spatial tasks involving mentally manipulated circles and arcs while simultaneously recording a continuous EEG record. Each task was designed to tap into

mental rotation subcomponents. The pattern of brain activity obtained from the alpha frequency band revealed that males asymmetrically engage the right frontal lobe during these spatial tasks, whereas females exhibited bilateral activation of both the frontal and temporal lobes.

Consistent with these results, Corsi-Cabrera, Ramos, Guevara, Arce, and Gutierrez (1993) collected EEG of eight females and eight males from parietal sites (P-3 and P-4) during an analytical task, a spatial task and one mixed task involving both kinds of processing. The females showed significantly higher alpha relative power than men during all conditions. Interhemispheric correlations between these parietal sites was significantly higher for females than for males for all tasks and for all frequency bands. This same group of researchers (1997) found women to show higher interhemispheric correlations for EEG alpha1 power from left and right central locations than men during spatial tasks.

Several EEG studies have used coherence analyses to explore sex differences in relative hemispheric activation. In these coherence studies higher coherence values are associated with greater cortical coupling. One of the first of these coherence studies reporting a sex difference was conducted by Beaumont, Mayes and Rugg (1978). Using 16 subjects, eight males and eight females, EEG was recorded from temporal and parietal sites while the subjects performed two verbal and two spatial tasks. Females showed higher interhemispheric coherence than males in the alpha band. This effect held true regardless of task and was significantly more pronounced from the parietal sites. Volf and Razumnikova (1999) collected EEG from 15 females and 15 males while the subjects

learned dichotically presented concrete nouns. Females showed a greater and more diffuse increase in interhemispheric coherence than males. These differences were found primarily in the alpha and theta bands. When resting coherence was compared to coherence during task performance, females showed a higher increase of rest to task coherence for the right hemisphere for both theta and alpha frequency bands. Females demonstrated higher interhemispheric coherence in the theta when frontal electrodes of the left hemisphere were paired with posterior electrodes of the right hemisphere. Using a mental rotation task and a coherence analysis Rescher and Rappelsberger (1999) found females to show a more symmetrical coherence increase from rest to task than males in the theta and beta frequency domains for the posterior regions of the brain. The authors suggested that this finding supports the behavioral findings of a more bilateral organization of female's brains.

Duffy, McAnulty and Albert (1996) looked at the effects of age, as well as gender and handedness, on interhemispheric coherence in a large-scale study with 371 subjects. Data were obtained from 20 scalp electrodes using the usual 10-20 placement. This study demonstrated a decrease of hemispheric coherence with age for both right-handed males and females. These age effects were seen in all parts of the brain and for all frequencies. The authors suggest that this decrease in interhemispheric coherence may be due in part to the age related decrease in size of the adult corpus callosum especially for the later years (Cowell, Allen, Zalatimo, & Denenburg, 1992). With respect to gender, there was higher interhemispheric coherence for right-handed females than right handed males supporting the hypothesis put forward that women are less strongly lateralized and hence

more bihemispheric than men. This pattern was found in frontal, central, temporal and occipital regions. However, interhemispheric coherence is higher for left handed males than for left handed females.

Attention and EEG measures.

Electroencephalography alpha rhythms have also been shown to be reflective of manipulations of attention. Gevins and Smith (2000) looked at the effect of practice effects on the alpha EEG band as the result of task-induced changes in working memory requirements. Working memory was defined as the outcome of the ability to control attention and sustain its focus on a particular active mental representation in the face of distracting influences. This study compared subjects who were low, medium, or high ability performers as assessed by the WAIS-R. High ability subjects initially showed activation in the dorsolateral frontal regions. As they developed an effective strategy for task performance they relied less on frontal regions and more on parietal regions. Low ability subjects tended to show the opposite pattern of practice related regional changes. These results suggest that the high ability individuals learned to adopt performance strategies which took advantage of distributed cortical processing resources. Low ability subjects relied more exclusively on limited capacity frontal lobe circuits. There was a practice related increase in alpha activity indicating a relative decline in the proportion of local cortical neurons activated during task performance.

A practice related increase in alpha activity was also found by Smith, McEvoy, and Gevins (1999) in a study examining changes in EEG measures associated with the

development of cognitive and visuomotor strategies and skills as subjects learned to perform new tasks. In the alpha band, there was an increase in alpha related to practice suggesting that when subjects are confronted with novel tasks, performance is initially associated with large populations of neurons. As effective strategies and skills are developed, there is a less extensive cortical contribution to task performance.

Wilson, Swain, and Ullsperger (1999) looked at EEG alpha changes in ten male subjects during a 4-second retention interval. Subjects held 3, 5, 7 or 8 digits in memory for the 4-second interval; holding larger numbers of items in memory was associated with lower alpha activity over left hemisphere parietal, central and temporal areas. This is consistent with other reports showing decreased alpha with increased task difficulty. These results are consistent with those found by Earle and Kikus (1982) who reported decreased alpha with increased difficulty of mental arithmetic tasks. Jausovec and Jausovec (2000) failed to find significant differences in EEG power or coherence as a result of manipulations of task difficulty. However, the tasks used were problem solving in nature and thus, were not typical tasks targeted at verbal or spatial abilites.

De Toffol, Autret, Gaymard and Degiovanni (1992) looked at the effects of maintaining lateral gaze on EEG alpha power for 12 right-handed males during resting conditions. Their paradigm was based on Kinsbourne's theory that a right lateral gaze would activate the left hemisphere while a left lateral gaze would activate the right hemisphere. They discovered that right gaze clearly activates the left hemisphere while left gaze had less of an effect on the right hemisphere. This effect on alpha power was more pronounced for the eyes closed condition than the eyes open condition. Therefore,

these investigators found for their male subjects that maintaining lateral gaze asymmetrically modified the alpha frequency band irrespective of cognitive activity.

The present study.

The large-scale study of Urbanczyk and Kennelly (1991) provides behavioral evidence that interhemispheric coupling, as indicated by significant positive intercorrelations of cognitive task performances, is enhanced when attention is allocated congruently with the lateralized cognitive task. The present study uses electroencephalographic data to investigate whether the allocation of attention affects the EEG record of the subjects and thereby provide physiological evidence that the hemispheres are coupled or working together under congruent allocations of attention. Consistent with Kinsbourne and Banich, the present study does not adopt particular language with respect to the definition of attention. Instead, the present study focuses on an operational definition of attention, i.e. the role of attention on hemispheric interaction.

The present study recorded continuous EEG activity during the administration of the single task condition in the Urbanczyk and Kennelly (1991) study. Although positive correlations between cognitive task performances are most readily demonstrated under dual task conditions, the single task condition from this study was chosen in order to avoid potential muscle artifacts arising from finger tapping. Additionally the tasks were difficult enough to ensure the engagement of attention. EEG recording was obtained during the same manipulations of attention related to task performance as in the Urbanczyk and Kennelly (1991) behavioral study. Both males and females oriented attention, by instructed lateral gaze, to the hemisphere either congruent or incongruent

with the task. The tasks used were a forward and backward digit span retention task and a forward and backward spatial span retention task. For the congruent group, attention was directed toward the right during the 20-second digit span memory task and toward the left during the 20-second spatial span memory task. For the incongruent group, attention was directed toward the left during the digit span memory task and toward the right during the spatial span memory task. The EEG recorded during the 20-second retention intervals was extracted and analyzed.

Because the behavioral study indicated a coupling effect for the cerebral hemispheres which varied systematically with gender and the allocation of attention, this study proposed that EEG coherence values would vary similarly under the same manipulations. A coherence analysis was chosen because it uses physiological data and it is a noninvasive technique for studying functional relationships between brain regions. The coherence function measures the correlation between two signals as a function of the frequency components they contain (Shaw, 1981). EEG coherence may detect task-induced changes in EEG related to functional organization in the brain. For example, the coherence between EEG signals from two brain areas would be expected to be less if one area became engaged in a cognitive task performance and the other remained quiescent than if both brain areas were involved in the cognitive task performance. Coherence values range from 0 to 1. Higher values indicate greater degrees of functional coupling.

This study is directed toward the alpha frequency band. The study of De Toffol et al. (1992) documents that the alpha frequency band is responsive to the effects of lateral gaze. Additionally it has been documented in the literature for some time that the alpha

rhythm is sensitive to attentional demands (Gevins and Smith, 2000; Ray and Cole, 1985; Earle, 1988). More recently, it has been reported (Klimesch, 2000) that it is particularly the lower alpha frequency range which is reflective of changes in attentional demands while the upper alpha range is reflective of specific task demands. Therefore, the present study will divide alpha into a low (8-10 Hz) component and a high component (11-13 Hz). The results of the present study will be discussed in the context of low and high alpha. Further, the alpha frequency band is appropriate for the present study because EEG studies concerned with sex differences have found these differences most consistently in the alpha frequency range (Beaumont, Mayes and Rugg, 1978; Erwin, Mawhinney-Hee, Gur and Gur, 1989; Volf and Rrazumnikova, 1999; Glass, Butler and Carter, 1984; Gevins, 1983).

The present study concentrates on the more posterior regions of the brain. In one of the earliest and most heavily cited coherence studies in the literature, Beaumont, Mayes and Rugg (1978) found sex differences in coherence from homologous parietal sites. The association cortices are presumably the areas of the brain expected to be involved in the processing of these cognitive tasks. The association cortices of the brain are reflected in the temporal, parietal, and occipital areas. In the present study the manipulations of attention either congruently or incongruently with the task presumes the tasks used can and do offer asymmetric or lateralized activation. The posterior regions of the brain appear to show the greatest electroencephalographic evidence of hemispheric asymmetry in response to cognitive demand, while anterior regions have not been as reliably affected by cognitive requirements (Davidson, 1988).

An analysis of the interhemispheric correlations of alpha power on the present data set was conducted and the results, presented previously, are consistent with the conjecture that the posterior region of the brain reflects asymmetric activation (DeLeon Hill, Clarke, and Kennelly, 1997). The pattern of interhemispheric correlations for all possible pairs of interhemispheric correlations (digit with spatial, digit with digit and spatial with spatial) for alpha power yielded essentially the same pattern of significant positive correlations between the digit and spatial-locations tasks found in the Urbanczyk and Kennelly study (1991) for the posterior region only (see Fig 2).

For both females and males, orienting in a direction that is hemispherically congruent with the concurrent memory task enhanced both the proportion of significant interhemispheric correlations and the mean of interhemispheric correlations of alpha power relative to incongruent orienting. Also, similar to the results of the Urbanczyk and Kennelly (1991) behavioral study, an effect of sex was found, both within orienting conditions and independent of the direction of orienting. Females had a higher proportion of significant interhemispheric correlations and a greater mean of interhemispheric correlations than did the males.

Hypotheses

I hypothesize that the EEG collected during the 20-second retention intervals of a digit and spatial span retention task will show greater interhemispheric coherence values when attention is directed toward the hemisphere which is performing the task than when attention is directed to the opposite hemisphere performing the cognitive task. Because

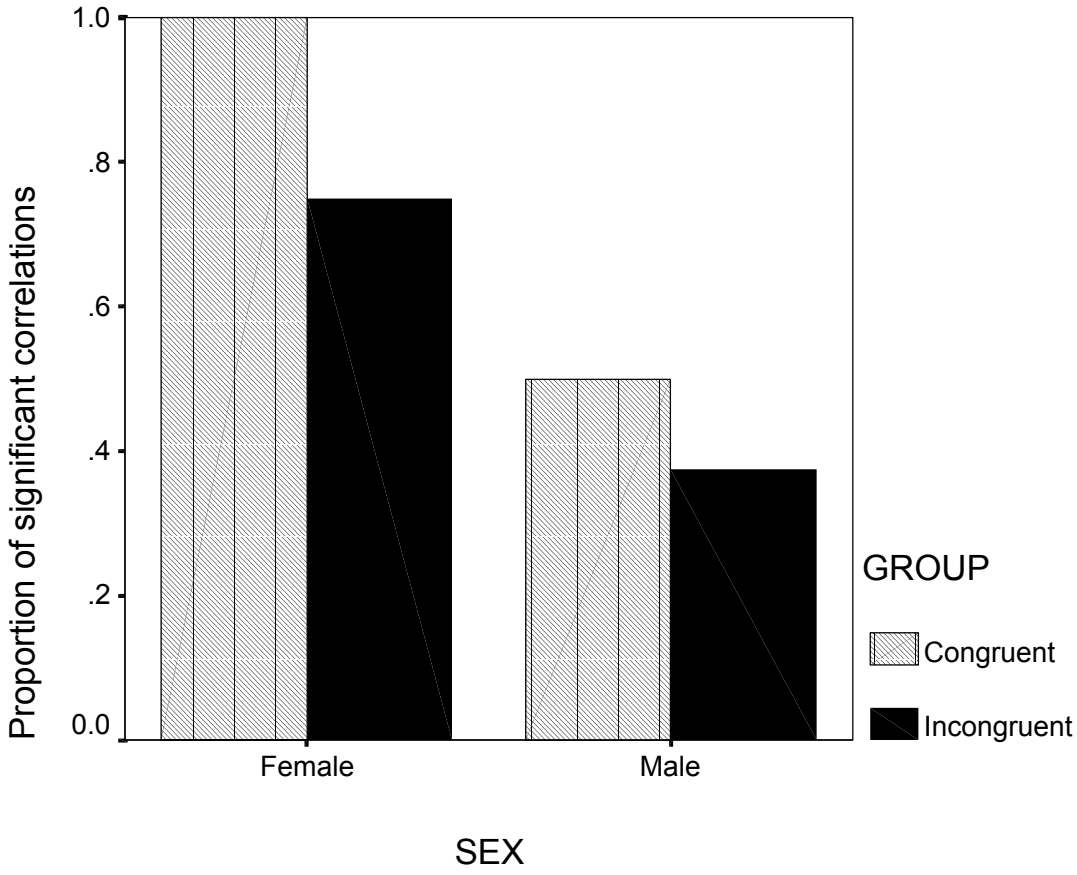


Fig. 2. The proportion of significant correlations for alpha power during the digit span and spatial span tasks from the left and right hemispheres from the posterior region as reported by DeLeon Hill, Clarke, and Kennelly, 1997.

ongoing cognitive function, as well as, manipulations of attention are often reflected by changes in alpha frequency, I will concentrate my analysis on the alpha frequency band. I predict that this evidence of greater interhemispheric coherence will be evident in the posterior region of the brain and that females will show greater interhemispheric coherence than males.

CHAPTER 2

Methods

Subjects and Design

Thirty right-handed subjects were studied. The 16 female and 14 male subjects were university undergraduates screened for handedness with the Edinburgh Handedness Inventory (Oldfield, 1971). Subjects were also screened for prior head injury or neurologic disorder. The behavioral results were analyzed using a multivariate analysis of variance design: a 2 (sex: females vs. males) x 2 (group: congruent vs. incongruent) x 4 (task: forward digits, forward spatial, backward digits, backward spatial) with repeated measures on the last factor of task. The coherence values calculated from the EEG data were also analyzed using a multivariate analysis of variance design: a 2 (sex: females vs. males) x 2 (group: congruent vs. incongruent) x 4 (task: forward digits, forward spatial, backward digits, backward spatial) x 4 (electrode pair: T3-T4, T5-T6, P3-P4, O1-O2) with repeated measures on the last factors of task and electrode pair.

Tasks

Short-term (20 s) retention of digit or spatial location sequences served as the cognitive tasks. Digit sequences were presented verbally and spatial location sequences visually. For the digit tasks, a digit sequence was presented to the subject orally, one digit per second. For the forward digit trials the subject was asked to repeat an eight or nine digit string back as presented. For the backward digits trials the subjects were asked

to repeat a seven or eight digit string in the reverse order of presentation. For the spatial location sequences the experimenter used a wooden board with nine 3.81 cm. (1.5″) unmarked wooden blocks fixed to it in an irregular pattern. The experimenter pointed to each block in a sequential manner. On the forward spatial trials subjects were required to repeat the sequences as presented by pointing to the blocks in the same order they were presented. On the backward spatial trials subjects were required to respond with a reversal of the sequences presented. The experimenter pointed to the blocks at the rate of one block per second.

The length of the retention spans was chosen to be of moderate difficulty and were the same length as those presented in Urbanczyk and Kennelly (1991). Based on the number of digits or blocks in the correct position, a partial or full credit score was assigned for each trial based on an interval scoring system designed by Paulman and Kennelly (1984) (Appendix A).

Behavioral Procedures

Subjects were randomly assigned, by sex, into two groups, a congruent orienting group and an incongruent orienting group. There were eight females and seven males in each group. In the congruent group, head and eye gaze orientation always activated the same hemisphere as the memory sequence being retained on each trial. In this group, subjects turned their heads and directed their gaze toward the right while retaining digit sequences, and to the left while retaining spatial location sequences. In the congruent condition both orienting and the memory task directed activation toward the same hemisphere. In the incongruent orienting group, head and eye gaze orientation activated

the hemisphere incongruent with the sequence being retained. Subjects turned their heads and directed their gaze leftward while retaining digit sequences, and rightward while retaining spatial location sequences. In the incongruent condition both hemispheres were always activated, one by orienting and the other by the performance of the memory task.

After completing the Handedness Inventory and consent form, the subject was seated in an armchair and the electrodes were placed on the subject. Following electrode placement a lap desk was placed on the armchair and the block board for the spatial span tasks was placed on the desk. To minimize noise in the EEG, the overhead lights were turned off and an incandescent lamp was used for light. The experimenter sat directly across from the subject. Instructions for the task procedures were given (see Appendix B) followed by two practice trials of each type; i.e. two forward digit tasks, two backward digit tasks, two forward spatial tasks, and two backward spatial tasks).

Following the practice trials EEG recording began. EEG was recorded for two minutes of baseline, one minute with eyes open and one minute with eyes closed. During baseline with eyes open subjects were instructed to fixate on a target directly in front of them and to avoid eye blinking. Following the recording of baseline EEG the trials began.

The sequence length for the first two trials of each type began as eight for forward digits, seven for backward digits, seven for forward spatial, and six for backward spatial. After the first two trials of each type, the sequence length of each type was increased by one for the next two trials. To ensure that adequate artifact free EEG data could be collected one

more trial of each type (forward digits, backward digits, forward spatial, and backward spatial) for each sequence length was conducted. The trials were ordered randomly with the following restriction: a retention task in each direction (forward and backward) was run before either direction was repeated. Order of presentation was the same for all subjects. For the trials as presented, see Appendix C. Before the presentation of the digit or spatial span subjects were told what the task was and whether they would repeat the span in the order it was presented or the reverse of the presentation. Following the presentation of the digit or spatial span subjects were instructed to turn their head and direct their gaze either rightward or leftward (depending on group and task). After the 20 s retention interval concluded, the experimenter asked the subject to repeat back the sequence. During the task performance for each trial the experimenter noted the 20 s interval during which the subject retained the digit or spatial location sequence. It was the EEG collected during the 20 s interval from each trial that was later analyzed.

EEG Procedures

Twenty electrodes were attached according to the International 10-20 system of electrode placement (Jasper, 1958) using an electrode cap with tin electrodes. A diagram of the 10-20 electrode placement appears in Appendix D. Linked ears served as the reference. Impedances were maintained below 3 K Ω ohms. Impedances were checked after the experiment concluded to ensure that the impedances were maintained. EEG recording was obtained using a Bio-logic Systems Corporation Brain Atlas with a gain setting of 30,000 with a bandpass of 1-100 Hz, the 60-hz notch filter on, and a sampling rate of 125 Hz.

EEG Data Analysis

The 20 s intervals of EEG collected from each trial were examined for eye blink and muscle tension artifacts by visual inspection. A minimum of 8 and a maximum of 12 2 s artifact free epochs for each type of trial were chosen for further processing. Each 2 s epoch was converted to an ascii file and then imported into the software package S-Plus for purposes of computing the coherence analysis. The script used in S-Plus to calculate the coherence values was written by Richard Herrington in the Academic Computing Office at the University of North Texas.

Coherence values were calculated for the total alpha frequency band (8-13 Hz), as well as for high alpha (11-13 Hz.) and low alpha (8-10 Hz.), for the electrode pairs of T3-T4, T5-T6, P3-P4 and O1-O2. The coherence values from the 2 s epochs for each subject for each trial type (forward digits, forward spatial, backward digits and backward spatial) were averaged to get a mean coherence value for each subject for each trial type.

Mathematically coherence is defined as the squared normalized cross-power spectrum and represents a correlation function in the frequency domain, i.e. a correlation coefficient per frequency or frequency band (Rappelsberger, Weiss, & Schack, 2000). To make the transition from signals in the time domain to spectra in the frequency domain the fast Fourier transform is applied. The result of the fast Fourier transformation is the computation of averaged power and cross power spectra. These components are used in the mathematical formula for coherence. The mathematical formula for coherence is presented in Appendix E.

Coherence values range from 0 to1. A coherence of "1" means that the corresponding frequency components of two time dependent signals are identical. The only differences which can exist are in amplitude and phase delay. A coherence of "0" means that the corresponding frequency components of the two signals are not correlated. Since coherence is a correlation coefficient per frequency or frequency band it can be used to describe the relationship or coupling between signals at that frequency or in that frequency band.

CHAPTER 3

Results

This investigation focused on the degree to which homologous sites in the posterior region of the two hemispheres appear to be functioning together in support of task performance as reflected by coherence values. Within the context of this investigation, higher coherence values are seen as indicative of greater interhemispheric coupling.

The criterion used for statistical significance is $p <$ or = .05. However, some results which do not meet this criterion are informative with respect to the working hypotheses and will be reported on the basis of reasonable effect size and power.

Behavioral data

The basic analysis of variance design is a multivariate 2 (sex: females vs. males) x 2 (group: congruent vs. incongruent) x 4 (task: forward digits, forward spatial, backward digits, backward spatial) with repeated measures on the last factor of task. Mean correct of total possible scores were analyzed for the behavioral tasks. None of the between subject effects (sex or group) or the interactions of task with group or sex were significant. However, the interaction of task with group yielded $F(3,24) = 2.910$, $p < .06$, eta squared = .267, and observed power = .618. This two-way interaction is graphed in Fig. 3. A Sidak test for group was not significant for any of the tasks. The within subject factor of task was significant $F(3,24) = 24.356$, $p < .000$, eta squared = .753, and observed power = 1.000. However, because the span lengths for the tasks were

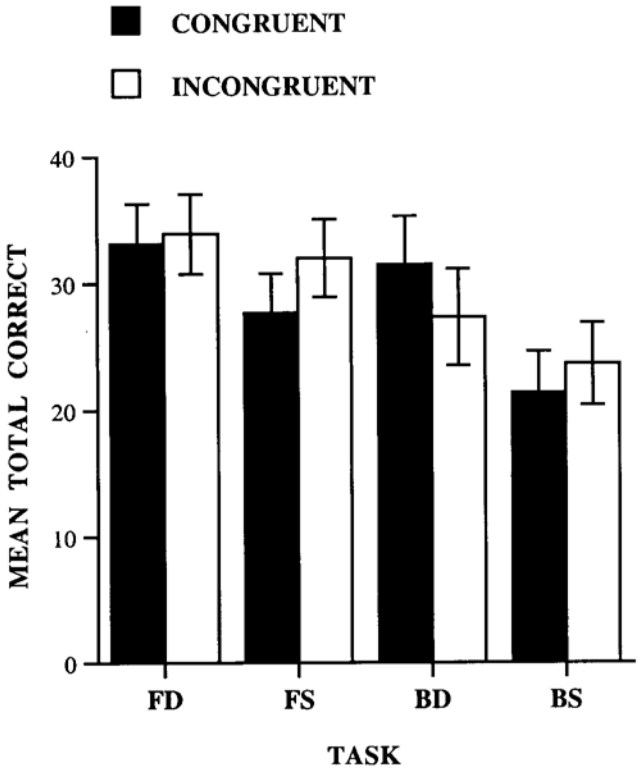


Fig. 3. The behavioral results of mean total correct scores for the congruent and incongruent groups for the forward digits (FD), forward spatial (FS), backward digits (BD), and backward spatial (FS) tasks. Data are for 15 subjects in each of the congruent and incongruent groups. The bars represent ± 2 S.E.

different and the tasks have different possible scores it is not directly meaningful to interpret differences among the tasks apart from their interaction with the factors of group and sex. Table 1 presents the total possible scores and percentage correct scores for each task and group. The summary table for the multivariate analysis of variance is presented in Appendix F. The summary tables for the simple effects are presented in Appendix G.

Coherence data

A multivariate 2 (sex) x 2 (group) x 4(task) x 4 (pairs of electrode sites: T3-T4, T5-T6, P3-P4, O1-O2) analysis of variance with repeated measures on the factors of task and pairs of electrode sites was conducted on the coherence values for each frequency band examined: total alpha (8-13 Hz), low alpha (8-10 Hz) and high alpha (11-13 Hz). Only low alpha and high alpha are reported here as total alpha provides no information beyond that contained in the low alpha and high alpha analyses. The patterns obtained in the low and high alpha analyses have some definite differences. Although the results of total alpha are not discussed in the text, the descriptive statistics for total alpha are presented in Appendix H and the summary tables for the analysis of variance for total alpha is presented in Appendix I.

Low Alpha For low alpha (8-10 Hz) there was a significant main effect for group (coherence greater for the congruent group than the incongruent group) $F(1,26) = 6.926$, $p < .02$, eta squared = .21 and observed power = .717. (Fig.4). Mean coherence for the congruent group was equal to .610, and mean coherence for the incongruent group was equal to .578. The descriptive statistics for the analysis of low alpha are presented in Appendix J. The summary table for the between group analysis is presented in

Table 1.
Behavioral Results

Total Possible Scores and Percentage Correct Scores

Task	Total Possible	Percentage Correct Congruent	Incongruent
FD	51	.6484	.6627
FS	45	.6148	.7081
BD	45	.6978	.6074
BS	39	.5453	.6051

Appendix K.

There was a significant main effect for site for low alpha, F(3,24) 485.373, $p < .000$, eta squared = .984, observed power = 1.000 (Fig. 5.). The coherence values increased from the more anterior to the more posterior sites (T3-T4 to T5-T6 to P3-P4 to O1-O2). The summary table for the within subject multivariate analysis for low alpha is presented in Appendix L.

There was a significant task by sex interaction for low alpha, F(3,24) = 3.622, $p < .03$, eta squared = .312, observed power = .723 (Fig. 6). The univariate F tests for the simple effects test of sex (adjusted per Sidak) was significant for the forward digit task F(1,26) = 4.286, $p < .05$. Males exhibited higher coherence than females when performing the forward digits task. The summary table for the simple effects of sex are presented in Appendix M. The univariate F tests for task (adjusted per Sidak) was significant for females F(3,24) = 4.470, $p < .02$. The pairwise comparison for forward spatial and backward spatial was significant for females, $p < .02$. Females performing the backward spatial task had higher coherence than they did when performing the forward spatial task. The pairwise comparisons and the summary table for the multivariate simple effects of task are presented in Appendix N.

High alpha For high alpha (11-13 Hz) there was a significant four-way interaction between sex, group, task and electrode pair, F(9,18) = 2.983, $p < .03$, eta squared = .599, and observed power = .852. The descriptive statistics for high alpha are presented in Appendix O. The summary tables for the multivariate analysis of variance are presented

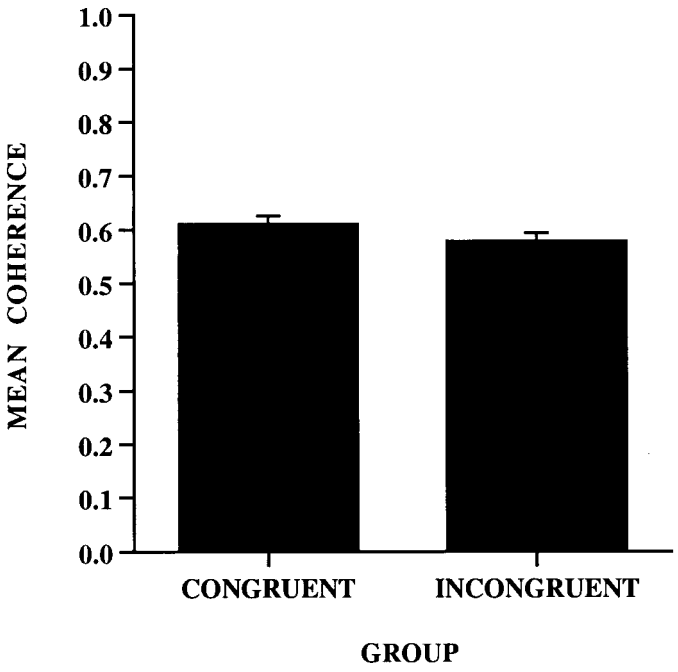


Fig. 4. Main effect for group for low alpha. In the figure, the mean ± 2 S.E. coherence values for the congruent and the incongruent groups are shown. Data are for 15 subjects in each of the congruent and incongruent groups

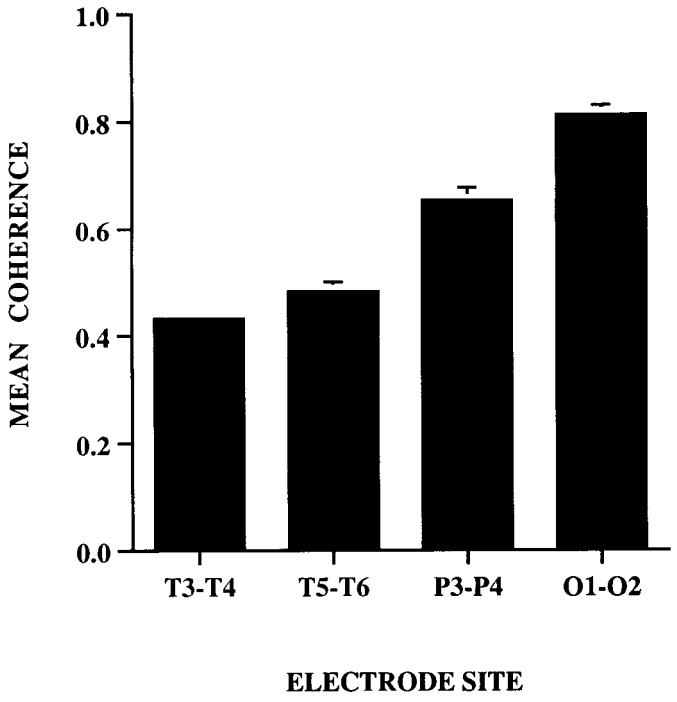


Fig. 5. Main effect for site for low alpha. In the figure the mean coherence ± 2 S.E. for each electrode pair is shown.

in Appendix P. To explicate the four-way interaction separate three way analyses were conducted for each task using the within subject factor of site and the between subject factors of sex and group. The analyses were conducted separately for each task because, as mentioned previously, differences among the tasks are not directly meaningful since the tasks have different possible scores and different span lengths. The effects of task are important only as they relate to the other factors. For purposes of simplicity each task will be discussed separately.

The analysis for forward digits yielded a significant main effect for site $F(3,24) = 131.027$, $p < .000$, eta squared = .942, and observed power = 1.000. The summary tables for forward digits for the three way analysis are presented in Appendix Q. Sidak tests of multiple comparisons among the electrode sites were significant for all comparisons $p < .000$ except the comparison between T3-T4 and T5-T6 which was not significant. The effect of site for forward digits is graphed in Fig.7. The three way analysis for forward digits also yielded a significant interaction for the between subject factors sex and group. The simple effects test for group (using the Sidak adjustment) was significant for males $F(1,26) = 4.942$, $p < .05$ (and not significant for females) with the congruent group exhibiting higher coherence than the incongruent group. This interaction of sex and group for forward digits in high alpha is graphed in Fig. 8. The tests for multiple comparisons for site are presented in Appendix R. The tests for the simple effects of group are presented in Appendix S.

There were no significant interactions for the forward spatial task. There was a significant main effect for site. Sidak tests of multiple comparisons among electrode sites

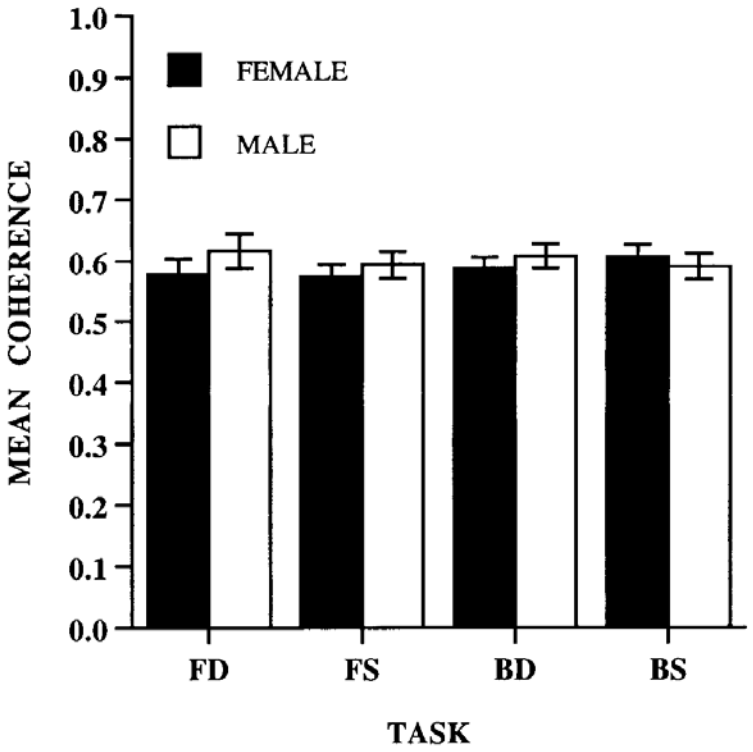


Fig. 6. Task by sex interaction for low alpha. The figure shows the forward digits (FD) task, the forward spatial (FS) task, the backward digits (BD) task, and the backward spatial (BS) task ± 2 S.E. for males and females. Males performing the forward digits task had significantly higher coherence than females performing the forward digits task. Females performing the backward spatial task had significantly higher coherence than females performing the forward spatial task.

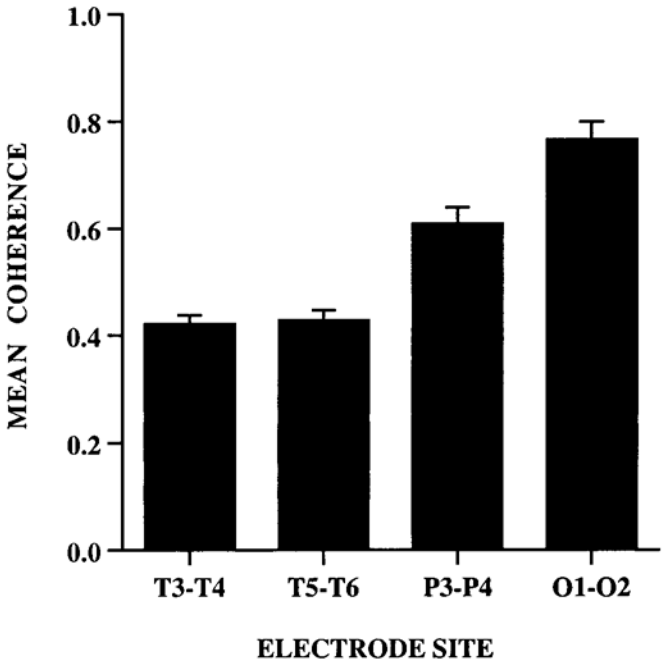


Fig. 7. Main effect for site for forward digits in high alpha. In the figure the mean coherence value ± 2 S.E. for each electrode pair is shown.

was significant for all comparisons p < .000 except the comparison between T3-T4 and T5-T6 which was not significant. The graph of the main effect of site is presented in Fig. 9. The summary tables for forward spatial for the three way analysis are presented in Appendix T. The tests for multiple comparisons for site are presented in Appendix U.

For the backward digits task there were no significant interactions. For the backward digits task there was a significant main effect for site $F(3,24) = 95.992$, $p < .000$, eta squared = .923 and observed power = 1.000. The pairwise comparisons for site (with a Sidak adjustment) were all significant except the comparison of T3-T4 with T5-T6 which was not significant. The effect for site is graphed in Fig.10. There was also a significant main effect for sex $F(1,26) = 6.797$, $p < .02$, eta squared = .207 and observed power = .709 with males demonstrating higher coherence than females. The effect of sex is graphed in Fig. 11. The summary tables for forward spatial for the three way analysis are presented in Appendix V. The tests for simple effects of sex are presented in Appendix W. The tests for the simple effects of site are presented in Appendix X.

There were no significant interactions for the backward spatial task. There was a significant main effect for site $F(3,24) = 172.144$, $p < .000$, eta squared = .956, and observed power = 1.000. The pairwise comparisons for site (with a Sidak adjustment) were significant for all possible pairs of electrode sites. The effect for site is graphed in Fig.12. The summary tables for forward spatial for the three way analysis are presented in Appendix Y. The tests for simple effects of site are presented in Appendix Z.

The non-parametric sign test was used to test the overall pattern of the congruent vs. incongruent groups and specifically to test the hypothesis that the proportion of

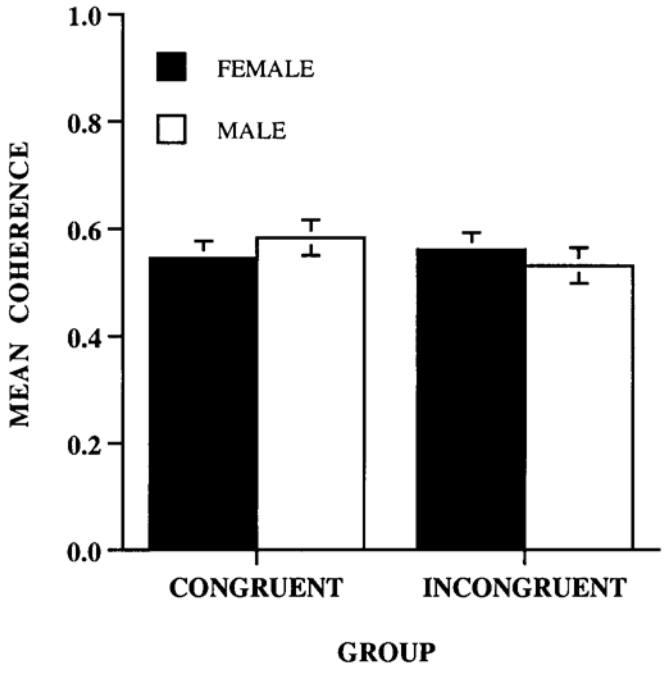


Fig. 8. Mean coherence ± 2 S.E. for the significant sex by group interaction for forward digits in high alpha. For males (and not for females) the congruent group yielded higher coherence measures than the incongruent group.

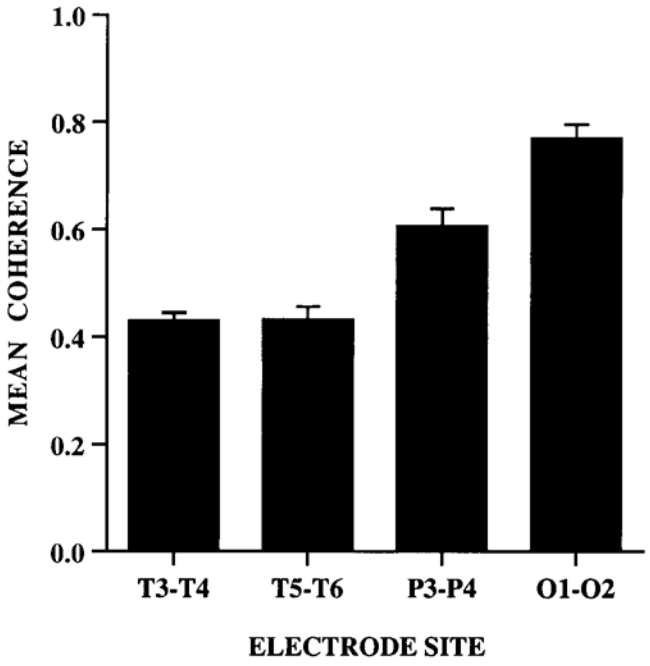


Fig. 9. Main effect for site for forward spatial in high alpha. In the figure the mean coherence ± 2 S.E. for each electrode pair is shown.

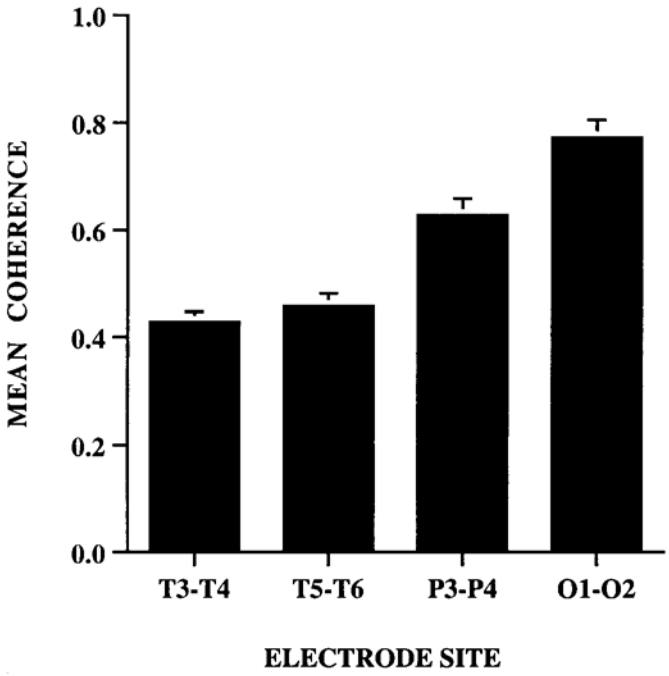


Fig. 10. Main effect for site for backward digits in high alpha. In the figure the mean ± 2 S.E. for each electrode pair is shown.

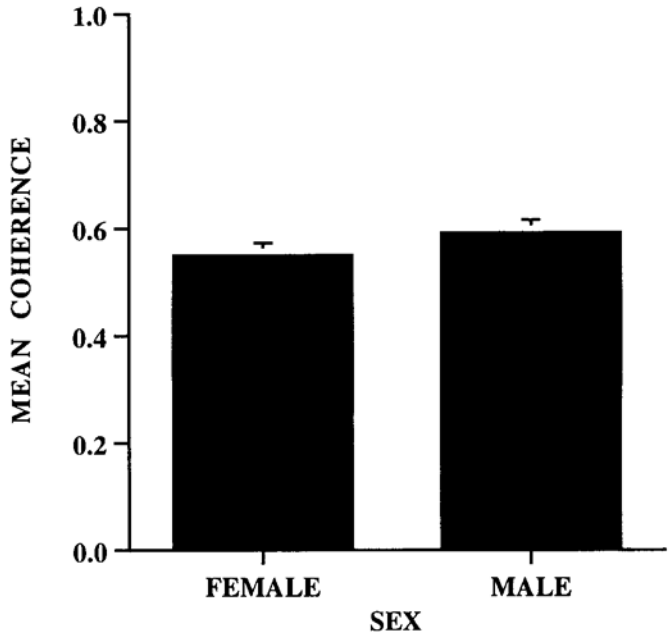


Fig. 11. The mean coherence ± 2 S.E. for the effect of sex for backward digits in high alpha. Males demonstrate higher coherence than females when performing the backward digits task.

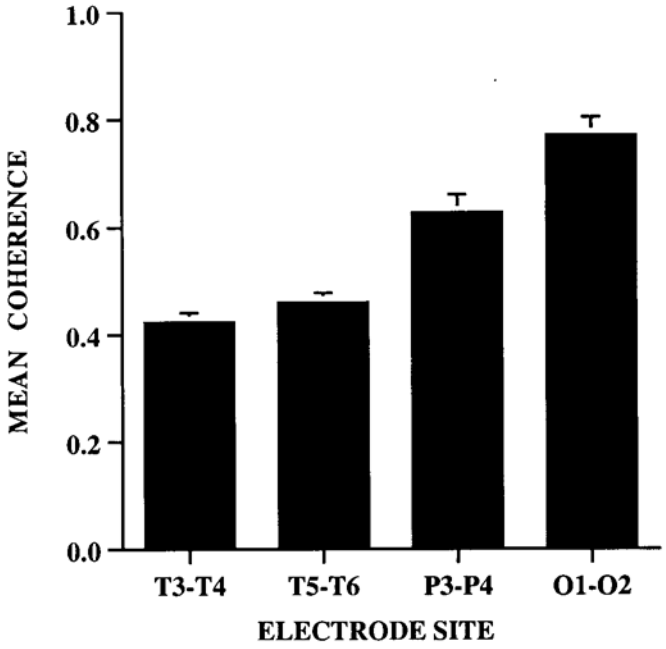


Fig. 12. Main effect for site for backward spatial in high alpha. The figure shows mean coherence ± 2 S.E. for each electrode pair.

matched pairs of congruent and incongruent means was greater for the congruent group. For low alpha, 27 of the 32 possible matched pairs of congruent and incongruent tasks were greater for the congruent group. The sign test was significant at the .01 level for low alpha and at the .05 level for high alpha. For high alpha 22 of the 32 possible matched pairs of congruent and incongruent tasks were greater for the congruent group.

In summary, for the low alpha frequency range, there was a main effect for group. Congruent orienting with a lateralized task produced higher coherence values than incongruent orienting. Also for the low alpha frequency range, there was a main effect for site, with coherence values increasing from the more anterior to the more posterior. Task interacted with sex in the low alpha frequency band. Males exhibited higher coherence than females when performing forward digits. Sex was not a significant factor for the remaining tasks.

For the high alpha frequency range there was a significant four way interaction between sex, group, task, and site. The subsequent three way interactions for each task yielded a significant main effect for site for all tasks, with coherence increasing from the more anterior sites to the posterior sites. For the forward digits task the interaction of sex and group was significant only for males. Males in the congruent group demonstrated higher coherence than males in the incongruent group. For the backward digits task there was a main effect for sex with males demonstrating higher coherence than females. There were no significant effects, other than for site, for the forward spatial and the backward spatial tasks.

The sign tests for the low alpha and the high alpha frequency ranges indicated that the overall pattern for both low and high frequency ranges was for the congruent group to demonstrate higher coherence vales than the incongruent group.

CHAPTER 4

Discussion

The major hypothesis of this study was that orienting attention congruently with lateralized task performance would produce greater interhemispheric EEG coherence measurements in the posterior regions of the brain than when attention was allocated incongruently with lateralized tasks. This hypothesis was confirmed. This effect of higher interhemispheric coherence for the congruent group was strongest for the low alpha frequency band as indicated by a significant main effect for group in the analysis of variance. This effect size for group in low alpha was large at .51. In the posterior regions examined, the proportion of higher interhemispheric coherence values, by sign test, for the congruent group relative to the incongruent group was significant for both the low alpha and the high alpha frequency bands, providing further evidence for this hypothesis. Increased interhemispheric coherence of the EEG signal between posterior homologous hemispheric sites under conditions of congruent orienting of attention offers physiological evidence that the two hemispheres share a common resource, ability, or system when attention is allocated to the hemisphere performing the task.

The other major hypothesis of this study was that females would exhibit higher interhemispheric coherence than males. This hypothesis was not confirmed. The present study provides some evidence in both the low and the high alpha frequency bands that males have higher interhemispheric coherence than females. For the low alpha

frequency band males demonstrated higher interhemispheric coherence than females when performing the forward digits task. In the high alpha frequency band males demonstrated higher coherence than females when performing the backward digits task. Why is this so?

The hypothesis that females would display greater coherence than males was based upon the prior research from which the present study was derived. Urbanczyk and Kennelly (1991) found, serendipitously, in a dual task paradigm, that females exhibited a higher proportion of significant positive correlations between the digit span task and the spatial span task than males did. However, the previous Urbanczyk, Angel , and Kennelly study (1988) used these same cognitive tasks in a dual task paradigm, without the instructed lateral gaze, and did not find this sex difference. It was only when instructed lateral gaze was combined with the dual task paradigm that the sex difference emerged.

The present study has a major procedural difference from the prior research it was modeled after. In Urbanczyk and Kennelly (1991) the single task condition (a forward digit task, a forward spatial task, a backward digit task, and backward spatial task performed alone) was randomly interspersed among dual task trials which combined the cognitive tasks with unimanual finger tapping. In the present study only the single task condition was performed. It is known that the dual task condition produces higher correlations between cognitive tasks than a single task condition (Stankov, 1978,1979; Hunt, 1980). It may be that the emergence of a sex difference with respect to interhemispheric coherence, which is in effect a correlation, requires more complex

experimental conditions for the subjects than the relatively simple single task condition of the present study.

The sex differences in interhemispheric coherence with respect to the specific tasks can be viewed within the context of sex differences in cognitive abilities. In the low alpha band males exhibited higher coherence than females on the forward digit task, and in the high alpha frequency band males exhibited higher coherence than females on the backward digits task. Additionally, for the high alpha frequency range, group was significant for males (and not for females) when performing the forward digits task (males in the congruent group had higher coherence than males in the incongruent group). Females typically outperform males on tasks of verbal fluency. While the digit span tasks are not verbal fluency tasks per se, they are affected by verbal fluency (Baddeley, 1997). This aptitude, favoring females may account for their lower interhemispheric coherence compared to males on a digit task. Because of their greater relative competency with respect to verbal fluency females may have relied on a system specific to, perhaps, the left hemisphere while males engaged a bilateratal system in support of these task performances. This differential impact of verbal fluency on the tasks for females and males may have produced the need for the bilateral system of attention to a greater extent for males than for females.

The increased competency regarding verbal fluency for females may have also affected the females' performance on the forward and backward spatial tasks. In the low alpha frequency band females performing the backward spatial task had higher interhemispheric coherence than they did when performing the forward spatial task.

When females performed the forward spatial task it is possible that they used a verbal strategy, i.e. assigning a digit to each spatial location. When the task required the additional manipulation of a reversal of the pattern this verbal strategy may not have been useful. In effect, females may have relied on a verbal strategy thereby using a unitary system residing in one of the hemispheres for the forward spatial task and a bilateral system for the backward spatial task. This scenario would result in higher interhemispheric coherence for the backward spatial task.

Although it is generally reported in the literature that females have higher coherence than males, these studies are typically broader in scope. For example, Volf and Razumnikova (1999) report a greater increase of rest to task coherence for females than for males during a verbal memory task. However, coherence was calculated between all possible electrode pairs for a total of 120 pairings for five frequency bands. Although females had higher coherence in all frequency bands these pairings were generally between the frontal electrodes of the left hemisphere paired with posterior electrodes of the right hemisphere. The Rescher and Rappelsberger (1999) study reporting sex differences also looked at all possible electrode pairings of the International 10-20 system. The more symmetrical allocation of coherence for females was seen with respect to all electrode pairings. The Duffy et. al (1996) study reported higher interhemispheric coherence for females in a study with 350 subjects. Again all possible electrode pairs were included in the analysis.

The present study was purposefully more limited in scope relating to the electrode pairings chosen for analysis. There is empirical evidence that females demonstrate

higher interhemispheric coherence between these posterior electrode pairings. Beaumont, Mayes, and Rugg (1978) found females to exhibit higher coherence between T5 and T6 as well as between P3 and P4 during a verbal and spatial task. The present study looked at parietal and temporal sites because the association cortices which are associated with the cognitive processing of the tasks used in this study are located in the posterior regions of the brain. Additionally the posterior regions more typically show asymmetries in activation.

The significant results of the present study demonstrating differences between the congruent and incongruent groups provides additional evidence that the digit span task and the spatial span task are, in fact, lateralized to the respective left and right hemispheres. The present experimental design is exactly counterbalanced for leftward looking and orienting and rightward looking and orienting. The congruent group always looks and orients rightward when performing the digit span task and always looks and orients leftward when performing the spatial task. The incongruent group always looks and orients leftward when performing the digit span task and always looks and orients rightward when performing the spatial span task. The orienting of attention either congruently or incongruently with the tasks is the only manipulation occurring in the single task condition of the present study. This systematic difference with respect to group would only occur if the tasks provided consistent lateralization.

Just as the absence of the dual task condition may have impacted the display of sex differences, the absence of the dual task paradigm may have impacted the size of the main effect of group for low alpha. Although the effect size is already large (.51), it

would be expected to increase under conditions of increased complexity. The evidence from this line of research suggests that as the demands of the experimental condition increase, the composition of the brain system in support of task performance changes. If difficulty, or complexity is low, resources in the hemisphere not specialized for the task may not be needed and interhemispheric coherence would be expected to be relatively low.

The behavioral result from the present study did not yield significant differences between the groups. This is not particularly surprising. The differences between orienting groups, which were found in the Urbanczyk and Kennelly (1991) study were not mean differences with only one exception. Instead these were differences in the correlations between the cognitive task performances. The present study does not have a sufficient sample size to evaluate differences in correlations, as did the Urbanczyk and Kennelly (1991) study.

For both the low alpha and high alpha frequency bands there are significant effects of site. The trend was for the interhemispheric coherence values to increase from the more anterior to the more posterior regions. Although the frontal lobes are involved in both attention and working memory there is also evidence that one of the attention systems (Posner and Petterson, 1990) and perhaps several of the working memory systems (Baddely, 1997) involve parietal brain components. It is reasonable to speculate that components of both the attention and the working memory systems which are located in posterior brain regions could be invoked with the present experimental manipulation.

This greater degree of interhemispheric coherence for the congruent orienting group was most evident in the low alpha frequency band, providing further evidence to an emerging literature suggesting that alpha is not a unitary concept. Within this conceptualization, low alpha (8-10 Hz) is viewed as reflective of attentional processing, whereas the upper alpha band reflects task related cognitive processes. In a review chapter on EEG alpha and cognitive processes, Klimesch (2000) reviews the work of his laboratory with respect to attention and lower alpha. In two experiments reported by Klimesch, Pfurtscheller, and Schimke (1992) alertness was manipulated by randomly varying the appearance of a warning signal for the imperative stimulus in two different tasks, a reading task and a category judgment task. The effects of the warning signal appeared only in the lower alpha band. The authors interpreted their findings to mean that the lower alpha band reflects changes in non task specific processes such as alertness and attention. Also from Klimesch's laboratory (1993), good memory performers, as compared to bad memory performers, showed a significantly stronger desychronization (sometimes referred to as alpha suppression) during encoding and retrieval in the lower alpha band. These results were interpreted by assuming that good memory performance may be due to an increase in alertness or attention and that a relative lack of alpha desynchronization, or suppression during cognitive performance may be related to a general lack of alertness or attention.

In the present study, the low alpha frequency band indicates an effect of the manipulation of attention which is independent of any interaction with task. This result is consistent with the notion that the low alpha frequency band is indicative of non-task

related cognitive processing such as attention. In the high alpha frequency band there was a four-way interaction of task, site, sex, and group. This interaction of task with the factors of orienting group, sex, and electrode site suggests that the high alpha frequency range may be reflective of cognitive processing specific to the tasks as suggested by Klimesch (2000).

The evidence of a functional coupling of homologous interhemispheric sites as reflected by coherence measures can be viewed within the context of Denenburg's general systems model. Coherence is analogous to a correlation, and therefore higher coherence indicates that the two hemispheres (or elements in Denenburg's language) are evidencing a greater degree of coupling into a common general system. This indication of a greater degree of hemispheric coupling as reflected by higher interhemispheric coherence under the congruent allocation of attention suggests that there is less functional separation between the two hemispheres when attention is focused toward the hemisphere which is performing the cognitive task processing. The consistent lateral orientation of attention may serve to integrate regions of the less activated hemisphere into networks of the more activated hemisphere. Shifts in cortical activation related to changes in the orientation of attention may dynamically mediate the functional coupling of the two hemispheres, or elements, into a general brain system.

This functional coupling of the hemispheres could occur via subcortical means or via the corpus callosum. Mesalum's (1985) model of attentional processes suggests that subcortical reticular activation is directed upward to the cortex where it may have hemispherically unifying effects. The corpus callosum may also have a role in the

allocation of attention. Although there is no information about the individual subjects' corpus callosum anatomy in the present study it is possible to speculate on the possible role of the corpus callosum in the dynamic allocation of attention.

Banich (1998) suggests that a dynamic distribution of attentional processing could occur via the callosum in a manner akin to that observed in connectionist networks. For example, in a model of attentional effects in a Stroop task it has been proposed that there are adjustments of weights in the network between an attentional module and a color identification module (Cohen, Dunbar and McClelland, 1990: Cohen, Servan-Schreiber, and McClelland, 1992). The attentional effects are seen as emerging from the interactions among the modules. This interaction could occur via the corpus callosum.

Looking at the impact of the corpus callosum on sustained attention, Rueckert, Sorensen, and Levy (1994) tested children ranging from six to ten years old on a vigilance task. This age span was chosen because magnetic resonance imaging (MRI) studies have found that the corpus callosum continues to myelinate at least up until age ten (Hayakawa, Konishi, Matsuda, Kuriyama, Konishi, Yamashita, Okumura, and Hamanaka, 1989). As the myelination increases so does the efficiency of the corpus callosum with respect to interhemispheric communication. They found a positive relationship between the efficiency of interhemispheric communication as reflected by increased age and the ability to sustain attention.

There have been links in the literature of selective attention and working memory with the classical view being that attention gates or controls what sensory information is allowed into short term memory stores (Downing, 2000). Recently, however, it has been

suggested that there is an important link between attention and working memory which operates in the opposite direction. According to this account the contents of working memory influences the allocation of selective attention (Desimone & Duncan, 1995; Desimone, 1996, Duncan, 1998).

Downing (2000) tested the prediction that the contents of visual working memory would influence the guidance of selective attention. Subjects held the picture of a face in working memory on each trial. Then two objects, one matching the sample and the other novel, were presented simultaneously. As measured by a probe task, attention shifted to the object matching the sample in working memory. This effect generalized across object type, attentional probe task, and the working memory task. These results can be viewed within the context of Kinsbourne's model of attention. Kinsbourne's model suggests that the distribution of cortical activation is brought about by cognitive activity, particularly lateralized activity. Duncan's results indicate an allocation of attention based upon the contents of working memory.

Conclusions

If attention serves to integrate regions of the brain into a unified whole under conditions of task complexity does this provide evidence that attention is that unitary general ability 'g' espoused by Spearman? The results of the present study are consistent with "g" as a general resource, ability, or system, which is perhaps attentional in nature. This general resource, ability, or system may dynamically mediate interhemispheric coupling under conditions of attentional demand providing a possible explanation for the observed shifts in positive correlations between cognitive tasks. The evidence of

increased EEG interhemispheric coherence between homologous hemispheric sites when attention is oriented congruently with a lateralized task suggests a functional coupling between areas of the two hemispheres modulated by attention.

Limitations of the present study

The present study is limited by its use of the single task condition. Future research could be directed toward the investigation of interhemispheric coherence under single vs. dual task conditions. It is predicted that the effect size of the differences between the orienting groups would be enhanced when tested within a dual task context. Additionally, sex differences demonstrating females to have higher interhemispheric coherence, which were not found in the present study, may emerge when the task complexity is increased from a single task to a dual task paradigm.

APPENDIX A

Scoring for Retention Tasks

General Rule

The span score on any single trial equals the total possible number of digits or blocks correct minus the minimum number of moves (as defined below) required to restore the subjects response to the correct sequence.

Definition of a Move

Each of the following situations constitutes one move to be subtracted from the maximum span score.

(1) Addition of an omitted number or block to the series.

Example: 201385 correct response

20 385 subject's response

Score: 6 –1 =5

(2) Removal of a confabulated or extraneous number or block from the series.

Example: 201385 correct response

2013857 subject's response

Score: 6 –1 =5

(3) Relocaton of an incorrectly placed number or block to another position.

Example: 201385 correct response

201358 subject's response

Score: 6 – 1 = 5

Example: 201385 correct response

501382 subject's response

Score: 6 – 2 = 4

APPENDIX B

Task Instructions

I'm going to be giving you one of four different tasks to do. In one task I'll read you a string of numbers which I'll want you to repeat back to me in the same order I say them. For example, if I say 3-7-4-8 what would you say? That's right, you repeat them in the same order I say them. In another task I'll give you a string of numbers and I"\'ll ask you to repeat them in the reverse order of the way I say them. For example, if I say 9-3-2-6 what would you say? Good. For the other two tasks we'll use these blocks. I'll point to them in a sequence like this. (Experimenter points to four block string.) Good. Sometimes I'll ask you to point to them in reverse order. For example, if I do this (experimenter points to a four block string) what would you do? Good.

So the four tasks are: repeating numbers the way I say them, repeating them backwards, pointing to blocks the way I point to them, and pointing them backwards. It is important that you do your very best on each of them. Listen carefully to this next part. After I read you the numbers or point to the blocks I am going to instruct you to turn your head to your left or to your right and to look off in that direction, i.e. turn and look leftward (or rightward). You will maintain that head and gaze direction for 20 seconds and I will time you with this stopwatch. I'll tell ahead of time what the task is and which direction you'll be looking. When the 20 seconds is up I'll say "repeat". That will be your cue to repeat the sequence back to me. Do you have any questions?

Before we start let's practice a few of these tasks so you can get the hang of them. Ready? (Experimenter informs the subject as to the type of task they will perform, the direction they will orient, and the direction to report the memory span. Experimenter

reads the string, prompts subject to orient, say “stop, repeat” after 20 seconds and records the subject’s response.)

Do you have any more questions about what I want you to do? Okay lets start.

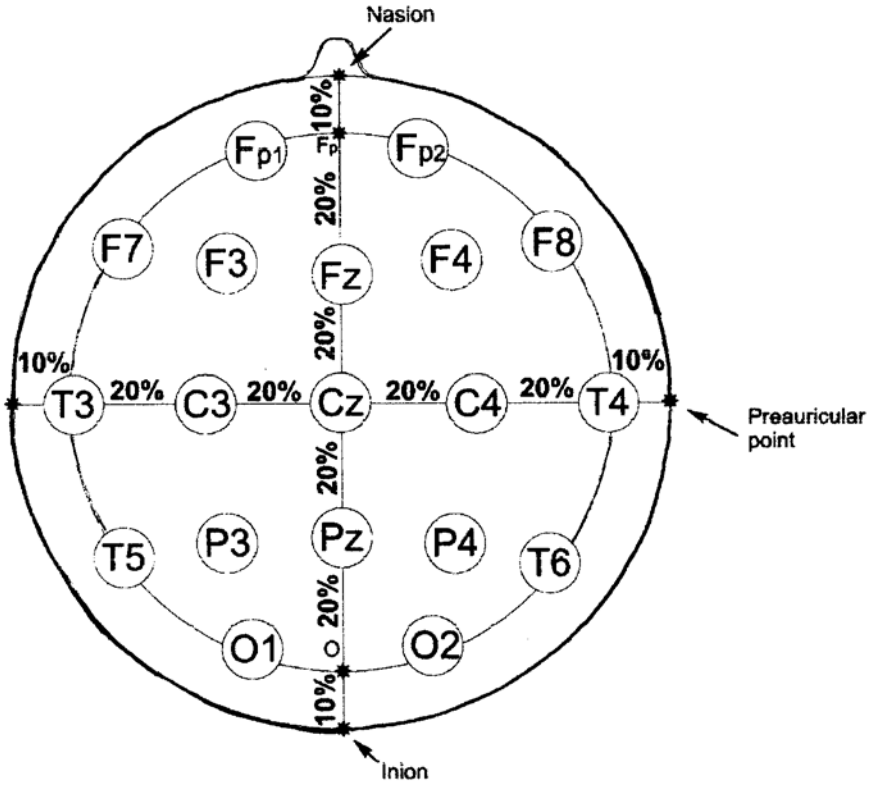
Appendix C

Direction of Span	**Nature of Task**	**Span**
Forward	Spatial	6354281
Back	Digit	9571823
Forward	Digit	85396451
Back	Spatial	965142
Forward	Digit	14786539
Back	Spatial	162375
Back	Digit	6382541
Forward	Spatial	2715386
Back	Spatial	7183952
Back	Digit	45698372
Forward	Spatial	81245367
Forward	Digit	128937546
Back	Spatial	3548761
Forward	Digit	295468317
Forward	Spatial	73241569
Back	Digit	41529768
Forward	Spatial	1978354
Back	Digit	5179486
Forward	Digit	75836129
Back	Spatial	615394

Back	Spatial	596143
Back	Digit	28369517
Forward	Spatial	63972851
Forward	Digit	283574819

Appendix D

Diagram of the International 10-20 Electrode Placement



APPENDIX E

The procedure for obtaining the coherence function is described by the following formula:

$$Coh(f) = \frac{\left| \sum_{i=1}^{N} F_1(f) * F_2^{*}(f) \right|^2}{\sum_{i=1}^{N} \left| F_1(f) \right|^2 * \sum_{I=1}^{N} \left| F_2(f) \right|^2}$$

where *Coh(f)* is the coherence function, *f* is the frequency, *N* is the number of EEG realizations involved in averaging, $F_1(f)$ and $F_2(f)$ are Fourier transforms of the EEG signals in two different channels, and * symbol denotes complex conjugation (Ivanitsky, Nikovaev and Ivaistsky, 1999).

Appendix F Multivariate Tests for Behavioral Data[c]

Effect		Value	F	Hypothesis df	Error df	Sig.	Eta Squared
TASK	Pillai's Trace	.753	24.356[b]	3.000	24.000	.000	.753
	Wilks' Lambda	.247	24.356[b]	3.000	24.000	.000	.753
	Hotelling's Trace	3.044	24.356[b]	3.000	24.000	.000	.753
	Roy's Largest Root	3.044	24.356[b]	3.000	24.000	.000	.753
TASK * SEX	Pillai's Trace	.024	.194[b]	3.000	24.000	.900	.024
	Wilks' Lambda	.976	.194[b]	3.000	24.000	.900	.024
	Hotelling's Trace	.024	.194[b]	3.000	24.000	.900	.024
	Roy's Largest Root	.024	.194[b]	3.000	24.000	.900	.024
TASK * GROUP	Pillai's Trace	.267	2.910[b]	3.000	24.000	.055	.267
	Wilks' Lambda	.733	2.910[b]	3.000	24.000	.055	.267
	Hotelling's Trace	.364	2.910[b]	3.000	24.000	.055	.267
	Roy's Largest Root	.364	2.910[b]	3.000	24.000	.055	.267
TASK * SEX * GROUP	Pillai's Trace	.079	.685[b]	3.000	24.000	.570	.079
	Wilks' Lambda	.921	.685[b]	3.000	24.000	.570	.079
	Hotelling's Trace	.086	.685[b]	3.000	24.000	.570	.079
	Roy's Largest Root	.086	.685[b]	3.000	24.000	.570	.079

Appendix F Multivariate Tests for Behavioral Data[c]

Effect		Noncent. Parameter	Observed Power[a]
TASK	Pillai's Trace	73.067	1.000
	Wilks' Lambda	73.067	1.000
	Hotelling's Trace	73.067	1.000
	Roy's Largest	73.067	1.000
TASK * SEX	Pillai's Trace	.581	.081
	Wilks' Lambda	.581	.081
	Hotelling's Trace	.581	.081
	Roy's Largest	.581	.081
TASK * GROUP	Pillai's Trace	8.731	.618
	Wilks' Lambda	8.731	.618
	Hotelling's Trace	8.731	.618
	Roy's Largest	8.731	.618
TASK * SEX * GROUP	Pillai's Trace	2.054	.173
	Wilks' Lambda	2.054	.173
	Hotelling's Trace	2.054	.173
	Roy's Largest	2.054	.173

a. Computed using alpha = .05

b. Exact statistic

c.
Design: Intercept+SEX+GROUP+SEX * GROUP
Within Subjects Design: TASK

Appendix F continued Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	2758.104	1	2758.104	1217.942	.000	.979	1217.942	1.000
SEX	4.688	1	4.688	2.070	.162	.074	2.070	.283
GROUP	.521	1	.521	.230	.636	.009	.230	.075
SEX * GROUP	1.075E-02	1	1.075E-02	.005	.946	.000	.005	.051
Error	58.879	26	2.265					

a. Computed using alpha = .05

Appendix G (a) Pairwise Comparisons for Simple Effects of Group for Behavioral Data

Measure: MEASURE_1

TASK	(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
						Lower Bound	Upper Bound
1	congruent	incongruent	-.759	2.226	.736	-5.334	3.816
	incongruent	congruent	.759	2.226	.736	-3.816	5.334
2	congruent	incongruent	-4.304	2.172	.058	-8.769	.162
	incongruent	congruent	4.304	2.172	.058	-.162	8.769
3	congruent	incongruent	4.161	2.692	.134	-1.373	9.695
	incongruent	congruent	-4.161	2.692	.134	-9.695	1.373
4	congruent	incongruent	-2.268	2.314	.336	-7.024	2.488
	incongruent	congruent	2.268	2.314	.336	-2.488	7.024

Based on estimated marginal means

a. Adjustment for multiple comparisons: Sidak.

Appendix G (b) Univariate Tests for Simple Effects of Group for Behavioral Data

Measure: MEASURE_1

TASK		Sum of Squares	df	Mean Square	F	Sig.
1	Contrast	4.301	1	4.301	.116	.736
	Error	961.804	26	36.992		
2	Contrast	138.288	1	138.288	3.925	.058
	Error	916.036	26	35.232		
3	Contrast	129.260	1	129.260	2.389	.134
	Error	1407.036	26	54.117		
4	Contrast	38.402	1	38.402	.961	.336
	Error	1039.321	26	39.974		

Each F tests the simple effects of group within each level combination of the other effects shown. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

Appendix H - Descriptive Statistics for Total Alpha

	sex	group	Mean	Std. Deviation	N
T3T4FD	female	congruent	.4209	3.195E-02	8
		incongruent	.4241	2.025E-02	8
		Total	.4225	2.589E-02	16
	male	congruent	.4490	3.536E-02	7
		incongruent	.4332	4.228E-02	7
		Total	.4411	3.833E-02	14
	Total	congruent	.4340	3.545E-02	15
		incongruent	.4283	3.151E-02	15
		Total	.4312	3.308E-02	30
T5T6FD	female	congruent	.4480	4.198E-02	8
		incongruent	.4519	3.512E-02	8
		Total	.4499	3.745E-02	16
	male	congruent	.5225	8.953E-02	7
		incongruent	.4223	3.235E-02	7
		Total	.4724	8.299E-02	14
	Total	congruent	.4828	7.615E-02	15
		incongruent	.4381	3.605E-02	15
		Total	.4604	6.279E-02	30
P3P4FD	female	congruent	.6440	8.284E-02	8
		incongruent	.6196	7.932E-02	8
		Total	.6318	7.935E-02	16
	male	congruent	.6623	7.056E-02	7
		incongruent	.6673	8.239E-02	7
		Total	.6648	7.374E-02	14
	Total	congruent	.6525	7.520E-02	15
		incongruent	.6419	8.162E-02	15
		Total	.6472	7.730E-02	30
O1O2FD	female	congruent	.7741	6.894E-02	8
		incongruent	.7708	8.565E-02	8
		Total	.7725	7.513E-02	16
	male	congruent	.8121	7.517E-02	7
		incongruent	.8136	6.451E-02	7
		Total	.8129	6.730E-02	14
	Total	congruent	.7918	7.200E-02	15
		incongruent	.7908	7.707E-02	15
		Total	.7913	7.329E-02	30

Appendix H - Descriptive Statistics for Total Alpha

	sex	group	Mean	Std. Deviation	N
T3T4FS	female	congruent	.4304	3.005E-02	8
		incongruent	.4250	3.915E-02	8
		Total	.4277	3.383E-02	16
	male	congruent	.4443	3.172E-02	7
		incongruent	.4321	2.001E-02	7
		Total	.4382	2.626E-02	14
	Total	congruent	.4369	3.056E-02	15
		incongruent	.4283	3.084E-02	15
		Total	.4326	3.048E-02	30
T5T6FS	female	congruent	.4452	3.968E-02	8
		incongruent	.4403	2.647E-02	8
		Total	.4427	3.269E-02	16
	male	congruent	.4701	6.366E-02	7
		incongruent	.4528	4.098E-02	7
		Total	.4614	5.220E-02	14
	Total	congruent	.4568	5.185E-02	15
		incongruent	.4461	3.335E-02	15
		Total	.4515	4.318E-02	30
P3P4FS	female	congruent	.6536	5.085E-02	8
		incongruent	.6213	.1089	8
		Total	.6375	8.376E-02	16
	male	congruent	.6221	4.801E-02	7
		incongruent	.6567	9.070E-02	7
		Total	.6394	7.200E-02	14
	Total	congruent	.6389	5.046E-02	15
		incongruent	.6378	9.892E-02	15
		Total	.6384	7.716E-02	30
O1O2FS	female	congruent	.7764	5.243E-02	8
		incongruent	.7880	8.378E-02	8
		Total	.7822	6.778E-02	16
	male	congruent	.7927	6.855E-02	7
		incongruent	.7802	6.003E-02	7
		Total	.7865	6.225E-02	14
	Total	congruent	.7840	5.881E-02	15
		incongruent	.7844	7.121E-02	15
		Total	.7842	6.417E-02	30

Appendix H - Descriptive Statistics for Total Alpha

	sex	group	Mean	Std. Deviation	N
T3T4BD	female	congruent	.4298	4.450E-02	8
		incongruent	.4160	2.515E-02	8
		Total	.4229	3.564E-02	16
	male	congruent	.4204	3.857E-02	7
		incongruent	.4433	2.298E-02	7
		Total	.4319	3.273E-02	14
	Total	congruent	.4254	4.063E-02	15
		incongruent	.4287	2.723E-02	15
		Total	.4271	3.403E-02	30
T5T6BD	female	congruent	.4621	3.348E-02	8
		incongruent	.4516	5.735E-02	8
		Total	.4568	4.570E-02	16
	male	congruent	.5211	6.541E-02	7
		incongruent	.4467	4.068E-02	7
		Total	.4839	6.504E-02	14
	Total	congruent	.4897	5.764E-02	15
		incongruent	.4493	4.858E-02	15
		Total	.4695	5.626E-02	30
P3P4BD	female	congruent	.6532	6.524E-02	8
		incongruent	.6499	8.333E-02	8
		Total	.6515	7.232E-02	16
	male	congruent	.6389	5.730E-02	7
		incongruent	.6783	9.115E-02	7
		Total	.6586	7.595E-02	14
	Total	congruent	.6465	5.992E-02	15
		incongruent	.6631	8.513E-02	15
		Total	.6548	7.282E-02	30
O1O2BD	female	congruent	.8052	5.500E-02	8
		incongruent	.7791	9.234E-02	8
		Total	.7922	7.465E-02	16
	male	congruent	.7925	7.343E-02	7
		incongruent	.8124	8.080E-02	7
		Total	.8025	7.489E-02	14
	Total	congruent	.7993	6.218E-02	15
		incongruent	.7947	8.577E-02	15
		Total	.7970	7.365E-02	30

Appendix H - Descriptive Statistics for Total Alpha

	sex	group	Mean	Std. Deviation	N
T3T4BS	female	congruent	.4323	3.432E-02	8
		incongruent	.4222	2.418E-02	8
		Total	.4273	2.915E-02	16
	male	congruent	.4101	3.867E-02	7
		incongruent	.4327	4.815E-02	7
		Total	.4214	4.356E-02	14
	Total	congruent	.4220	3.689E-02	15
		incongruent	.4271	3.627E-02	15
		Total	.4245	3.604E-02	30
T5T6BS	female	congruent	.4787	1.698E-02	8
		incongruent	.4753	3.902E-02	8
		Total	.4770	2.913E-02	16
	male	congruent	.4682	5.579E-02	7
		incongruent	.4737	5.492E-02	7
		Total	.4709	5.326E-02	14
	Total	congruent	.4738	3.883E-02	15
		incongruent	.4746	4.533E-02	15
		Total	.4742	4.147E-02	30
P3P4BS	female	congruent	.6618	5.585E-02	8
		incongruent	.6448	8.670E-02	8
		Total	.6533	7.100E-02	16
	male	congruent	.6686	5.325E-02	7
		incongruent	.6931	5.752E-02	7
		Total	.6809	5.474E-02	14
	Total	congruent	.6650	5.279E-02	15
		incongruent	.6673	7.615E-02	15
		Total	.6662	6.439E-02	30
O1O2BS	female	congruent	.7704	5.100E-02	8
		incongruent	.7833	9.384E-02	8
		Total	.7768	7.326E-02	16
	male	congruent	.8400	5.595E-02	7
		incongruent	.7944	4.620E-02	7
		Total	.8172	5.469E-02	14
	Total	congruent	.8029	6.273E-02	15
		incongruent	.7885	7.315E-02	15
		Total	.7957	6.735E-02	30

```
>Error # 801 in column 33.  Text: VERTICAL
>Unrecognized text appears on the SET command.  See the syntax help for
>system for valid keywords.
```

```
>This command not executed.


>Error # 801 in column 45.  Text: =
>Unrecognized text appears on the SET command.  See the syntax help for
>system for valid keywords.


>Error # 801 in column 48.  Text: HORIZONTAL
>Unrecognized text appears on the SET command.  See the syntax help for
>system for valid keywords.


>Error # 801 in column 62.  Text: =
>Unrecognized text appears on the SET command.  See the syntax help for
>system for valid keywords.
```

Appendix I - Multivariate Tests for Total Alpha[c]

Effect		Value	F	Hypothesis df	Error df	Sig.	Eta Squared
TASK	Pillai's Trace	.263	2.861[b]	3.000	24.000	.058	.263
	Wilks' Lambda	.737	2.861[b]	3.000	24.000	.058	.263
	Hotelling's Trace	.358	2.861[b]	3.000	24.000	.058	.263
	Roy's Largest Root	.358	2.861[b]	3.000	24.000	.058	.263
TASK * SEX	Pillai's Trace	.112	1.013[b]	3.000	24.000	.404	.112
	Wilks' Lambda	.888	1.013[b]	3.000	24.000	.404	.112
	Hotelling's Trace	.127	1.013[b]	3.000	24.000	.404	.112
	Roy's Largest Root	.127	1.013[b]	3.000	24.000	.404	.112
TASK * GROUP	Pillai's Trace	.051	.432[b]	3.000	24.000	.732	.051
	Wilks' Lambda	.949	.432[b]	3.000	24.000	.732	.051
	Hotelling's Trace	.054	.432[b]	3.000	24.000	.732	.051
	Roy's Largest Root	.054	.432[b]	3.000	24.000	.732	.051
TASK * SEX * GROUP	Pillai's Trace	.135	1.244[b]	3.000	24.000	.316	.135
	Wilks' Lambda	.865	1.244[b]	3.000	24.000	.316	.135
	Hotelling's Trace	.156	1.244[b]	3.000	24.000	.316	.135
	Roy's Largest Root	.156	1.244[b]	3.000	24.000	.316	.135
SITE	Pillai's Trace	.971	272.065[b]	3.000	24.000	.000	.971
	Wilks' Lambda	.029	272.065[b]	3.000	24.000	.000	.971
	Hotelling's Trace	34.008	272.065[b]	3.000	24.000	.000	.971
	Roy's Largest Root	34.008	272.065[b]	3.000	24.000	.000	.971
SITE * SEX	Pillai's Trace	.024	.200[b]	3.000	24.000	.895	.024
	Wilks' Lambda	.976	.200[b]	3.000	24.000	.895	.024
	Hotelling's Trace	.025	.200[b]	3.000	24.000	.895	.024
	Roy's Largest Root	.025	.200[b]	3.000	24.000	.895	.024

Appendix I - Multivariate Tests for Total Alpha[c]

Effect		Value	F	Hypothesis df	Error df	Sig.	Eta Squared
SITE * GROUP	Pillai's Trace	.112	1.011[b]	3.000	24.000	.405	.112
	Wilks' Lambda	.888	1.011[b]	3.000	24.000	.405	.112
	Hotelling's Trace	.126	1.011[b]	3.000	24.000	.405	.112
	Roy's Largest Root	.126	1.011[b]	3.000	24.000	.405	.112
SITE * SEX * GROUP	Pillai's Trace	.184	1.808[b]	3.000	24.000	.173	.184
	Wilks' Lambda	.816	1.808[b]	3.000	24.000	.173	.184
	Hotelling's Trace	.226	1.808[b]	3.000	24.000	.173	.184
	Roy's Largest Root	.226	1.808[b]	3.000	24.000	.173	.184
TASK * SITE	Pillai's Trace	.471	1.782[b]	9.000	18.000	.142	.471
	Wilks' Lambda	.529	1.782[b]	9.000	18.000	.142	.471
	Hotelling's Trace	.891	1.782[b]	9.000	18.000	.142	.471
	Roy's Largest Root	.891	1.782[b]	9.000	18.000	.142	.471
TASK * SITE * SEX	Pillai's Trace	.383	1.242[b]	9.000	18.000	.331	.383
	Wilks' Lambda	.617	1.242[b]	9.000	18.000	.331	.383
	Hotelling's Trace	.621	1.242[b]	9.000	18.000	.331	.383
	Roy's Largest Root	.621	1.242[b]	9.000	18.000	.331	.383
TASK * SITE * GROUP	Pillai's Trace	.450	1.637[b]	9.000	18.000	.178	.450
	Wilks' Lambda	.550	1.637[b]	9.000	18.000	.178	.450
	Hotelling's Trace	.819	1.637[b]	9.000	18.000	.178	.450
	Roy's Largest Root	.819	1.637[b]	9.000	18.000	.178	.450
TASK * SITE * SEX * GROUP	Pillai's Trace	.556	2.509[b]	9.000	18.000	.046	.556
	Wilks' Lambda	.444	2.509[b]	9.000	18.000	.046	.556
	Hotelling's Trace	1.254	2.509[b]	9.000	18.000	.046	.556
	Roy's Largest Root	1.254	2.509[b]	9.000	18.000	.046	.556

Appendix I - Multivariate Tests for Total Alpha[c]

Effect		Noncent. Parameter	Observed Power[a]
TASK	Pillai's Trace	8.584	.610
	Wilks' Lambda	8.584	.610
	Hotelling's Trace	8.584	.610
	Roy's Largest Root	8.584	.610
TASK * SEX	Pillai's Trace	3.038	.241
	Wilks' Lambda	3.038	.241
	Hotelling's Trace	3.038	.241
	Roy's Largest Root	3.038	.241
TASK * GROUP	Pillai's Trace	1.295	.123
	Wilks' Lambda	1.295	.123
	Hotelling's Trace	1.295	.123
	Roy's Largest Root	1.295	.123
TASK * SEX * GROUP	Pillai's Trace	3.732	.290
	Wilks' Lambda	3.732	.290
	Hotelling's Trace	3.732	.290
	Roy's Largest Root	3.732	.290
SITE	Pillai's Trace	816.196	1.000
	Wilks' Lambda	816.196	1.000
	Hotelling's Trace	816.196	1.000
	Roy's Largest Root	816.196	1.000
SITE * SEX	Pillai's Trace	.600	.082
	Wilks' Lambda	.600	.082
	Hotelling's Trace	.600	.082
	Roy's Largest Root	.600	.082

Appendix I - Multivariate Tests for Total Alpha[c]

Effect		Noncent. Parameter	Observed Power[a]
SITE * GROUP	Pillai's Trace	3.033	.240
	Wilks' Lambda	3.033	.240
	Hotelling's Trace	3.033	.240
	Roy's Largest Root	3.033	.240
SITE * SEX * GROUP	Pillai's Trace	5.425	.410
	Wilks' Lambda	5.425	.410
	Hotelling's Trace	5.425	.410
	Roy's Largest Root	5.425	.410
TASK * SITE	Pillai's Trace	16.041	.595
	Wilks' Lambda	16.041	.595
	Hotelling's Trace	16.041	.595
	Roy's Largest Root	16.041	.595
TASK * SITE * SEX	Pillai's Trace	11.181	.422
	Wilks' Lambda	11.181	.422
	Hotelling's Trace	11.181	.422
	Roy's Largest Root	11.181	.422
TASK * SITE * GROUP	Pillai's Trace	14.736	.551
	Wilks' Lambda	14.736	.551
	Hotelling's Trace	14.736	.551
	Roy's Largest Root	14.736	.551
TASK * SITE * SEX * GROUP	Pillai's Trace	22.578	.773
	Wilks' Lambda	22.578	.773
	Hotelling's Trace	22.578	.773
	Roy's Largest Root	22.578	.773

a. Computed using alpha = .05

b. Exact statistic

Appendix I - Multivariate Tests for Total Alpha[c]

c.

Design: Intercept+SEX+GROUP+SEX * GROUP
Within Subjects Design: TASK+SITE+TASK*SITE

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	163.339	1	163.339	10158.697	.000	.997	10158.697	1.000
SEX	3.135E-02	1	3.135E-02	1.950	.174	.070	1.950	.270
GROUP	5.927E-03	1	5.927E-03	.369	.549	.014	.369	.090
SEX * GROUP	4.977E-05	1	4.977E-05	.003	.956	.000	.003	.050
Error	.418	26	1.608E-02					

a. Computed using alpha = .05

Appendix J - Descriptive Statistics for Low Alpha

	Sex	Group	Mean	Std. Deviation	N
T3T4FD	female	congruent	.4131	3.958E-02	8
		incongruent	.4180	3.251E-02	8
		Total	.4156	3.508E-02	16
	male	congruent	.4503	4.097E-02	7
		incongruent	.4527	6.556E-02	7
		Total	.4515	5.254E-02	14
	Total	congruent	.4305	4.326E-02	15
		incongruent	.4342	5.188E-02	15
		Total	.4323	4.697E-02	30
T5T6FD	female	congruent	.4665	5.212E-02	8
		incongruent	.4569	5.510E-02	8
		Total	.4617	5.205E-02	16
	male	congruent	.5797	.1334	7
		incongruent	.4597	5.144E-02	7
		Total	.5197	.1153	14
	Total	congruent	.5193	.1114	15
		incongruent	.4582	5.152E-02	15
		Total	.4888	9.073E-02	30
P3P4FD	female	congruent	.6399	7.695E-02	8
		incongruent	.6375	7.137E-02	8
		Total	.6387	7.171E-02	16
	male	congruent	.6923	7.339E-02	7
		incongruent	.6215	8.547E-02	7
		Total	.6569	8.490E-02	14
	Total	congruent	.6644	7.746E-02	15
		incongruent	.6300	7.580E-02	15
		Total	.6472	7.730E-02	30
O1O2FD	female	congruent	.8120	6.122E-02	8
		incongruent	.7744	7.024E-02	8
		Total	.7932	6.655E-02	16
	male	congruent	.8639	7.598E-02	7
		incongruent	.8058	5.909E-02	7
		Total	.8348	7.199E-02	14
	Total	congruent	.8362	7.118E-02	15
		incongruent	.7890	6.502E-02	15
		Total	.8126	7.114E-02	30

Appendix J - Descriptive Statistics for Low Alpha

	Sex	Group	Mean	Std. Deviation	N
T3T4FS	female	congruent	.4416	4.126E-02	8
		incongruent	.4162	4.807E-02	8
		Total	.4289	4.522E-02	16
	male	congruent	.4559	5.386E-02	7
		incongruent	.4389	4.359E-02	7
		Total	.4474	4.789E-02	14
	Total	congruent	.4483	4.636E-02	15
		incongruent	.4268	4.590E-02	15
		Total	.4376	4.662E-02	30
T5T6FS	female	congruent	.4579	4.625E-02	8
		incongruent	.4493	3.667E-02	8
		Total	.4536	4.057E-02	16
	male	congruent	.4743	6.047E-02	7
		incongruent	.4774	6.567E-02	7
		Total	.4758	6.067E-02	14
	Total	congruent	.4655	5.205E-02	15
		incongruent	.4624	5.226E-02	15
		Total	.4640	5.127E-02	30
P3P4FS	female	congruent	.6567	5.598E-02	8
		incongruent	.6102	6.719E-02	8
		Total	.6335	6.440E-02	16
	male	congruent	.6624	6.181E-02	7
		incongruent	.6255	.1169	7
		Total	.6440	9.183E-02	14
	Total	congruent	.6594	5.668E-02	15
		incongruent	.6174	9.041E-02	15
		Total	.6384	7.716E-02	30
O1O2FS	female	congruent	.7921	3.232E-02	8
		incongruent	.7682	7.600E-02	8
		Total	.7801	5.776E-02	16
	male	congruent	.8243	7.777E-02	7
		incongruent	.7866	.1094	7
		Total	.8055	9.327E-02	14
	Total	congruent	.8071	5.823E-02	15
		incongruent	.7768	9.006E-02	15
		Total	.7920	7.609E-02	30

Appendix J - Descriptive Statistics for Low Alpha

	Sex	Group	Mean	Std. Deviation	N
T3T4BD	female	congruent	.4316	5.530E-02	8
		incongruent	.4127	2.471E-02	8
		Total	.4221	4.252E-02	16
	male	congruent	.4279	5.678E-02	7
		incongruent	.4456	2.289E-02	7
		Total	.4367	4.258E-02	14
	Total	congruent	.4299	5.398E-02	15
		incongruent	.4280	2.860E-02	15
		Total	.4290	4.246E-02	30
T5T6BD	female	congruent	.4962	8.048E-02	8
		incongruent	.4676	7.520E-02	8
		Total	.4819	7.667E-02	16
	male	congruent	.5303	7.478E-02	7
		incongruent	.4443	4.363E-02	7
		Total	.4873	7.380E-02	14
	Total	congruent	.5121	7.710E-02	15
		incongruent	.4568	6.155E-02	15
		Total	.4844	7.409E-02	30
P3P4BD	female	congruent	.6686	4.950E-02	8
		incongruent	.6106	5.503E-02	8
		Total	.6396	5.877E-02	16
	male	congruent	.6914	8.250E-02	7
		incongruent	.6530	8.950E-02	7
		Total	.6722	8.506E-02	14
	Total	congruent	.6792	6.543E-02	15
		incongruent	.6304	7.367E-02	15
		Total	.6548	7.282E-02	30
O1O2BD	female	congruent	.8383	5.403E-02	8
		incongruent	.7819	5.365E-02	8
		Total	.8101	5.961E-02	16
	male	congruent	.8773	5.784E-02	7
		incongruent	.7900	8.318E-02	7
		Total	.8336	8.239E-02	14
	Total	congruent	.8565	5.742E-02	15
		incongruent	.7857	6.650E-02	15
		Total	.8211	7.087E-02	30

Appendix J - Descriptive Statistics for Low Alpha

	Sex	Group	Mean	Std. Deviation	N
T3T4BS	female	congruent	.4574	4.335E-02	8
		incongruent	.4154	4.469E-02	8
		Total	.4364	4.775E-02	16
	male	congruent	.3932	5.809E-02	7
		incongruent	.4196	4.708E-02	7
		Total	.4064	5.261E-02	14
	Total	congruent	.4274	5.903E-02	15
		incongruent	.4173	4.419E-02	15
		Total	.4224	5.149E-02	30
T5T6BS	female	congruent	.5140	4.017E-02	8
		incongruent	.5077	6.694E-02	8
		Total	.5108	5.343E-02	16
	male	congruent	.4504	6.212E-02	7
		incongruent	.4750	8.339E-02	7
		Total	.4627	7.178E-02	14
	Total	congruent	.4843	5.948E-02	15
		incongruent	.4924	7.419E-02	15
		Total	.4884	6.620E-02	30
P3P4BS	female	congruent	.6793	2.826E-02	8
		incongruent	.6435	5.616E-02	8
		Total	.6614	4.675E-02	16
	male	congruent	.6980	6.366E-02	7
		incongruent	.6452	9.364E-02	7
		Total	.6716	8.166E-02	14
	Total	congruent	.6880	4.722E-02	15
		incongruent	.6443	7.305E-02	15
		Total	.6662	6.439E-02	30
O1O2BS	female	congruent	.8318	4.064E-02	8
		incongruent	.7991	4.903E-02	8
		Total	.8155	4.667E-02	16
	male	congruent	.8464	5.145E-02	7
		incongruent	.7959	8.616E-02	7
		Total	.8211	7.304E-02	14
	Total	congruent	.8386	4.490E-02	15
		incongruent	.7976	6.623E-02	15
		Total	.8181	5.938E-02	30

Appendix K - Tests of Between-Subjects Effects for Low Alpha

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	168.653	1	168.653	9834.480	.000	.997	9834.480	1.000
SEX	2.784E-02	1	2.784E-02	1.623	.214	.059	1.623	.233
GROUP	.119	1	.119	6.926	.014	.210	6.926	.717
SEX * GROUP	2.740E-03	1	2.740E-03	.160	.693	.006	.160	.067
Error	.446	26	1.715E-02					

a. Computed using alpha = .05

Appendix L - Multivariate Tests for Within-Subject Factors for Low Alpha[c]

Effect		Value	F	Hypothesis df	Error df	Sig.	Eta Squared
TASK	Pillai's Trace	.205	2.064[b]	3.000	24.000	.132	.205
	Wilks' Lambda	.795	2.064[b]	3.000	24.000	.132	.205
	Hotelling's Trace	.258	2.064[b]	3.000	24.000	.132	.205
	Roy's Largest Root	.258	2.064[b]	3.000	24.000	.132	.205
TASK * SEX	Pillai's Trace	.312	3.622[b]	3.000	24.000	.027	.312
	Wilks' Lambda	.688	3.622[b]	3.000	24.000	.027	.312
	Hotelling's Trace	.453	3.622[b]	3.000	24.000	.027	.312
	Roy's Largest Root	.453	3.622[b]	3.000	24.000	.027	.312
TASK * GROUP	Pillai's Trace	.143	1.334[b]	3.000	24.000	.287	.143
	Wilks' Lambda	.857	1.334[b]	3.000	24.000	.287	.143
	Hotelling's Trace	.167	1.334[b]	3.000	24.000	.287	.143
	Roy's Largest Root	.167	1.334[b]	3.000	24.000	.287	.143
TASK * SEX * GROUP	Pillai's Trace	.101	.897[b]	3.000	24.000	.457	.101
	Wilks' Lambda	.899	.897[b]	3.000	24.000	.457	.101
	Hotelling's Trace	.112	.897[b]	3.000	24.000	.457	.101
	Roy's Largest Root	.112	.897[b]	3.000	24.000	.457	.101
SITE	Pillai's Trace	.984	485.373[b]	3.000	24.000	.000	.984
	Wilks' Lambda	.016	485.373[b]	3.000	24.000	.000	.984
	Hotelling's Trace	60.672	485.373[b]	3.000	24.000	.000	.984
	Roy's Largest Root	60.672	485.373[b]	3.000	24.000	.000	.984
SITE * SEX	Pillai's Trace	.025	.202[b]	3.000	24.000	.894	.025
	Wilks' Lambda	.975	.202[b]	3.000	24.000	.894	.025
	Hotelling's Trace	.025	.202[b]	3.000	24.000	.894	.025
	Roy's Largest Root	.025	.202[b]	3.000	24.000	.894	.025

Appendix L - Multivariate Tests for Within-Subject Factors for Low Alpha[c]

Effect		Value	F	Hypothesis df	Error df	Sig.	Eta Squared
SITE * GROUP	Pillai's Trace	.117	1.062[b]	3.000	24.000	.384	.117
	Wilks' Lambda	.883	1.062[b]	3.000	24.000	.384	.117
	Hotelling's Trace	.133	1.062[b]	3.000	24.000	.384	.117
	Roy's Largest Root	.133	1.062[b]	3.000	24.000	.384	.117
SITE * SEX * GROUP	Pillai's Trace	.089	.782[b]	3.000	24.000	.516	.089
	Wilks' Lambda	.911	.782[b]	3.000	24.000	.516	.089
	Hotelling's Trace	.098	.782[b]	3.000	24.000	.516	.089
	Roy's Largest Root	.098	.782[b]	3.000	24.000	.516	.089
TASK * SITE	Pillai's Trace	.326	.968[b]	9.000	18.000	.496	.326
	Wilks' Lambda	.674	.968[b]	9.000	18.000	.496	.326
	Hotelling's Trace	.484	.968[b]	9.000	18.000	.496	.326
	Roy's Largest Root	.484	.968[b]	9.000	18.000	.496	.326
TASK * SITE * SEX	Pillai's Trace	.362	1.134[b]	9.000	18.000	.390	.362
	Wilks' Lambda	.638	1.134[b]	9.000	18.000	.390	.362
	Hotelling's Trace	.567	1.134[b]	9.000	18.000	.390	.362
	Roy's Largest Root	.567	1.134[b]	9.000	18.000	.390	.362
TASK * SITE * GROUP	Pillai's Trace	.506	2.051[b]	9.000	18.000	.093	.506
	Wilks' Lambda	.494	2.051[b]	9.000	18.000	.093	.506
	Hotelling's Trace	1.025	2.051[b]	9.000	18.000	.093	.506
	Roy's Largest Root	1.025	2.051[b]	9.000	18.000	.093	.506
TASK * SITE * SEX * GROUP	Pillai's Trace	.453	1.655[b]	9.000	18.000	.174	.453
	Wilks' Lambda	.547	1.655[b]	9.000	18.000	.174	.453
	Hotelling's Trace	.827	1.655[b]	9.000	18.000	.174	.453
	Roy's Largest Root	.827	1.655[b]	9.000	18.000	.174	.453

Appendix L - Multivariate Tests for Within-Subject Factors for Low Alpha[c]

Effect		Noncent. Parameter	Observed Power[a]
TASK	Pillai's Trace	6.191	.462
	Wilks' Lambda	6.191	.462
	Hotelling's Trace	6.191	.462
	Roy's Largest Root	6.191	.462
TASK * SEX	Pillai's Trace	10.867	.723
	Wilks' Lambda	10.867	.723
	Hotelling's Trace	10.867	.723
	Roy's Largest Root	10.867	.723
TASK * GROUP	Pillai's Trace	4.002	.309
	Wilks' Lambda	4.002	.309
	Hotelling's Trace	4.002	.309
	Roy's Largest Root	4.002	.309
TASK * SEX * GROUP	Pillai's Trace	2.691	.216
	Wilks' Lambda	2.691	.216
	Hotelling's Trace	2.691	.216
	Roy's Largest Root	2.691	.216
SITE	Pillai's Trace	1456.118	1.000
	Wilks' Lambda	1456.118	1.000
	Hotelling's Trace	1456.118	1.000
	Roy's Largest Root	1456.118	1.000
SITE * SEX	Pillai's Trace	.605	.082
	Wilks' Lambda	.605	.082
	Hotelling's Trace	.605	.082
	Roy's Largest Root	.605	.082

Appendix L - Multivariate Tests for Within-Subject Factors for Low Alpha[c]

Effect		Noncent. Parameter	Observed Power[a]
SITE * GROUP	Pillai's Trace	3.185	.251
	Wilks' Lambda	3.185	.251
	Hotelling's Trace	3.185	.251
	Roy's Largest Root	3.185	.251
SITE * SEX * GROUP	Pillai's Trace	2.345	.192
	Wilks' Lambda	2.345	.192
	Hotelling's Trace	2.345	.192
	Roy's Largest Root	2.345	.192
TASK * SITE	Pillai's Trace	8.709	.328
	Wilks' Lambda	8.709	.328
	Hotelling's Trace	8.709	.328
	Roy's Largest Root	8.709	.328
TASK * SITE * SEX	Pillai's Trace	10.204	.385
	Wilks' Lambda	10.204	.385
	Hotelling's Trace	10.204	.385
	Roy's Largest Root	10.204	.385
TASK * SITE * GROUP	Pillai's Trace	18.456	.669
	Wilks' Lambda	18.456	.669
	Hotelling's Trace	18.456	.669
	Roy's Largest Root	18.456	.669
TASK * SITE * SEX * GROUP	Pillai's Trace	14.891	.556
	Wilks' Lambda	14.891	.556
	Hotelling's Trace	14.891	.556
	Roy's Largest Root	14.891	.556

a. Computed using alpha = .05

b. Exact statistic

Appendix L - Multivariate Tests for Within-Subject Factors for Low Alpha[c]

c.

Design: Intercept+SEX+GROUP+SEX * GROUP
Within Subjects Design: TASK+SITE+TASK*SITE

Appendix M - Univariate Tests for Simple Effects of Sex for Low Alpha

Measure: MEASURE_1

TASK		Sum of Squares	df	Mean Square	F	Sig.
1	Contrast	1.104E-02	1	1.104E-02	4.286	.048
	Error	6.696E-02	26	2.575E-03		
2	Contrast	2.734E-03	1	2.734E-03	1.645	.211
	Error	4.321E-02	26	1.662E-03		
3	Contrast	2.701E-03	1	2.701E-03	2.059	.163
	Error	3.411E-02	26	1.312E-03		
4	Contrast	1.805E-03	1	1.805E-03	1.090	.306
	Error	4.307E-02	26	1.657E-03		

Each F tests the simple effects of Sex within each level combination of the other effects shown. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

Appendix N (a) - Pairwise Comparisons for Simple Effects of Task for Low Alpha

Measure: MEASURE_1

Sex	(I) TASK	(J) TASK	Mean Difference (I-J)	Std. Error	Sig.[a]
female	1	2	3.255E-03	.014	1.000
		3	-1.117E-02	.011	.893
		4	-2.874E-02	.013	.221
	2	1	-3.255E-03	.014	1.000
		3	-1.442E-02	.009	.498
		4	-3.199E-02*	.009	.010
	3	1	1.117E-02	.011	.893
		2	1.442E-02	.009	.498
		4	-1.757E-02	.009	.281
	4	1	2.874E-02	.013	.221
		2	3.199E-02*	.009	.010
		3	1.757E-02	.009	.281
male	1	2	2.257E-02	.015	.620
		3	8.265E-03	.012	.980
		4	2.526E-02	.014	.426
	2	1	-2.257E-02	.015	.620
		3	-1.430E-02	.009	.582
		4	2.695E-03	.010	1.000
	3	1	-8.265E-03	.012	.980
		2	1.430E-02	.009	.582
		4	1.700E-02	.009	.388
	4	1	-2.526E-02	.014	.426
		2	-2.695E-03	.010	1.000
		3	-1.700E-02	.009	.388

Based on estimated marginal means

Appendix N (a) - Pairwise Comparisons for Simple Effects of Task for Low Alpha

Measure: MEASURE_1

Sex	(I) TASK	(J) TASK	95% Confidence Interval for Difference[a]	
			Lower Bound	Upper Bound
female	1	2	-3.714E-02	4.365E-02
		3	-4.190E-02	1.957E-02
		4	-6.672E-02	9.244E-03
	2	1	-4.365E-02	3.714E-02
		3	-3.913E-02	1.029E-02
		4	-5.792E-02	-6.062E-03
	3	1	-1.957E-02	4.190E-02
		2	-1.029E-02	3.913E-02
		4	-4.228E-02	7.145E-03
	4	1	-9.244E-03	6.672E-02
		2	6.062E-03	5.792E-02
		3	-7.145E-03	4.228E-02
male	1	2	-2.062E-02	6.576E-02
		3	-2.460E-02	4.113E-02
		4	-1.534E-02	6.587E-02
	2	1	-6.576E-02	2.062E-02
		3	-4.072E-02	1.211E-02
		4	-2.502E-02	3.041E-02
	3	1	-4.113E-02	2.460E-02
		2	-1.211E-02	4.072E-02
		4	-9.423E-03	4.342E-02
	4	1	-6.587E-02	1.534E-02
		2	-3.041E-02	2.502E-02
		3	-4.342E-02	9.423E-03

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Sidak.

Appendix N (b) Multivariate Tests for Simple Effects of Task for Low Alpha

Sex		Value	F	Hypothesis df
female	Pillai's trace	.358	4.470[a]	3.000
	Wilks' lambda	.642	4.470[a]	3.000
	Hotelling's trace	.559	4.470[a]	3.000
	Roy's largest root	.559	4.470[a]	3.000
male	Pillai's trace	.151	1.419[a]	3.000
	Wilks' lambda	.849	1.419[a]	3.000
	Hotelling's trace	.177	1.419[a]	3.000
	Roy's largest root	.177	1.419[a]	3.000

Each F tests the multivariate simple effects of TASK within each level combination of the other effects shown. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

Appendix N (b) Multivariate Tests for Simple Effects of Task for Low Alpha

Sex		Error df	Sig.
female	Pillai's trace	24.000	.012
	Wilks' lambda	24.000	.012
	Hotelling's trace	24.000	.012
	Roy's largest root	24.000	.012
male	Pillai's trace	24.000	.262
	Wilks' lambda	24.000	.262
	Hotelling's trace	24.000	.262
	Roy's largest root	24.000	.262

Each F tests the multivariate simple effects of TASK within each level combination of the other effects shown. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Exact statistic

Appendix O - Descriptive Statistics for High Alpha

	sex	group	Mean	Std. Deviation	N
T3T4FD	female	congruent	.3970	4.912E-02	8
		incongruent	.4275	3.940E-02	8
		Total	.4123	4.580E-02	16
	male	congruent	.4356	3.240E-02	7
		incongruent	.4232	4.389E-02	7
		Total	.4294	3.762E-02	14
	Total	congruent	.4150	4.531E-02	15
		incongruent	.4255	4.008E-02	15
		Total	.4203	4.237E-02	30
T5T6FD	female	congruent	.4188	4.886E-02	8
		incongruent	.4485	4.998E-02	8
		Total	.4336	5.016E-02	16
	male	congruent	.4553	7.711E-02	7
		incongruent	.3872	3.802E-02	7
		Total	.4212	6.827E-02	14
	Total	congruent	.4358	6.402E-02	15
		incongruent	.4199	5.358E-02	15
		Total	.4279	5.857E-02	30
O1O2FD	female	congruent	.7603	9.669E-02	8
		incongruent	.7475	4.932E-02	8
		Total	.7539	7.444E-02	16
	male	congruent	.8121	6.139E-02	7
		incongruent	.7389	.1362	7
		Total	.7755	.1084	14
	Total	congruent	.7845	8.370E-02	15
		incongruent	.7435	9.585E-02	15
		Total	.7640	9.083E-02	30
P3P4FD	female	congruent	.6070	8.621E-02	8
		incongruent	.6215	7.055E-02	8
		Total	.6142	7.647E-02	16
	male	congruent	.6313	5.926E-02	7
		incongruent	.5747	9.972E-02	7
		Total	.6030	8.410E-02	14
	Total	congruent	.6183	7.334E-02	15
		incongruent	.5996	8.564E-02	15
		Total	.6090	7.892E-02	30

Appendix O - Descriptive Statistics for High Alpha

	sex	group	Mean	Std. Deviation	N
T3T4FS	female	congruent	.3980	3.763E-02	8
		incongruent	.4405	4.832E-02	8
		Total	.4192	4.723E-02	16
	male	congruent	.4363	3.067E-02	7
		incongruent	.4455	3.111E-02	7
		Total	.4409	3.007E-02	14
	Total	congruent	.4159	3.875E-02	15
		incongruent	.4428	3.987E-02	15
		Total	.4294	4.099E-02	30
T5T6FS	female	congruent	.4206	5.428E-02	8
		incongruent	.4252	4.068E-02	8
		Total	.4229	4.639E-02	16
	male	congruent	.4592	9.376E-02	7
		incongruent	.4268	2.964E-02	7
		Total	.4430	6.888E-02	14
	Total	congruent	.4386	7.508E-02	15
		incongruent	.4259	3.471E-02	15
		Total	.4323	5.783E-02	30
P3P4FS	female	congruent	.6087	8.606E-02	8
		incongruent	.5791	7.200E-02	8
		Total	.5939	7.817E-02	16
	male	congruent	.6221	7.364E-02	7
		incongruent	.6115	.1142	7
		Total	.6168	9.246E-02	14
	Total	congruent	.6150	7.794E-02	15
		incongruent	.5942	9.197E-02	15
		Total	.6046	8.442E-02	30
O1O2FS	female	congruent	.7483	7.889E-02	8
		incongruent	.7403	3.691E-02	8
		Total	.7443	5.964E-02	16
	male	congruent	.8134	7.574E-02	7
		incongruent	.7744	8.977E-02	7
		Total	.7939	8.232E-02	14
	Total	congruent	.7787	8.186E-02	15
		incongruent	.7562	6.667E-02	15
		Total	.7675	7.424E-02	30

Appendix O - Descriptive Statistics for High Alpha

	sex	group	Mean	Std. Deviation	N
T3T4BD	female	congruent	.4237	5.044E-02	8
		incongruent	.4260	4.731E-02	8
		Total	.4248	4.726E-02	16
	male	congruent	.4244	5.869E-02	7
		incongruent	.4350	5.295E-02	7
		Total	.4297	5.398E-02	14
	Total	congruent	.4240	5.243E-02	15
		incongruent	.4302	4.840E-02	15
		Total	.4271	4.967E-02	30
T5T6BD	female	congruent	.4344	5.128E-02	8
		incongruent	.4375	5.439E-02	8
		Total	.4360	5.109E-02	16
	male	congruent	.5037	8.317E-02	7
		incongruent	.4489	6.127E-02	7
		Total	.4763	7.571E-02	14
	Total	congruent	.4667	7.457E-02	15
		incongruent	.4428	5.588E-02	15
		Total	.4548	6.587E-02	30
P3P4BD	female	congruent	.6147	6.439E-02	8
		incongruent	.5816	5.884E-02	8
		Total	.5981	6.200E-02	16
	male	congruent	.6635	9.799E-02	7
		incongruent	.6465	.1142	7
		Total	.6550	.1026	14
	Total	congruent	.6375	8.261E-02	15
		incongruent	.6119	9.191E-02	15
		Total	.6247	8.684E-02	30
O1O2BD	female	congruent	.7386	8.127E-02	8
		incongruent	.7389	5.494E-02	8
		Total	.7388	6.702E-02	16
	male	congruent	.8572	5.679E-02	7
		incongruent	.7536	.1355	7
		Total	.8054	.1134	14
	Total	congruent	.7939	9.184E-02	15
		incongruent	.7458	9.716E-02	15
		Total	.7699	9.607E-02	30

Appendix O - Descriptive Statistics for High Alpha

	sex	group	Mean	Std. Deviation	N
T3T4BS	female	congruent	.4097	4.267E-02	8
		incongruent	.4084	3.880E-02	8
		Total	.4091	3.940E-02	16
	male	congruent	.4247	3.320E-02	7
		incongruent	.4483	8.150E-02	7
		Total	.4365	6.103E-02	14
	Total	congruent	.4167	3.798E-02	15
		incongruent	.4270	6.343E-02	15
		Total	.4219	5.164E-02	30
T5T6BS	female	congruent	.4404	3.021E-02	8
		incongruent	.4425	5.191E-02	8
		Total	.4414	4.104E-02	16
	male	congruent	.4711	7.334E-02	7
		incongruent	.4799	4.466E-02	7
		Total	.4755	5.851E-02	14
	Total	congruent	.4547	5.489E-02	15
		incongruent	.4600	5.075E-02	15
		Total	.4573	5.201E-02	30
P3P4BS	female	congruent	.6145	6.606E-02	8
		incongruent	.5990	9.786E-02	8
		Total	.6068	8.106E-02	16
	male	congruent	.6723	6.871E-02	7
		incongruent	.6202	.1204	7
		Total	.6463	9.795E-02	14
	Total	congruent	.6415	7.137E-02	15
		incongruent	.6089	.1054	15
		Total	.6252	9.001E-02	30
O1O2BS	female	congruent	.7719	8.925E-02	8
		incongruent	.7473	7.752E-02	8
		Total	.7596	8.175E-02	16
	male	congruent	.8007	6.537E-02	7
		incongruent	.7599	.1223	7
		Total	.7803	9.658E-02	14
	Total	congruent	.7853	7.769E-02	15
		incongruent	.7532	9.727E-02	15
		Total	.7693	8.803E-02	30

Appendix P - Multivariate Tests for High Alpha[c]

Effect		Value	F	Hypothesis df	Error df	Sig.	Eta Squared
TASK	Pillai's Trace	.209	2.112[b]	3.000	24.000	.125	.209
	Wilks' Lambda	.791	2.112[b]	3.000	24.000	.125	.209
	Hotelling's Trace	.264	2.112[b]	3.000	24.000	.125	.209
	Roy's Largest Root	.264	2.112[b]	3.000	24.000	.125	.209
TASK * SEX	Pillai's Trace	.254	2.725[b]	3.000	24.000	.067	.254
	Wilks' Lambda	.746	2.725[b]	3.000	24.000	.067	.254
	Hotelling's Trace	.341	2.725[b]	3.000	24.000	.067	.254
	Roy's Largest Root	.341	2.725[b]	3.000	24.000	.067	.254
TASK * GROUP	Pillai's Trace	.064	.551[b]	3.000	24.000	.652	.064
	Wilks' Lambda	.936	.551[b]	3.000	24.000	.652	.064
	Hotelling's Trace	.069	.551[b]	3.000	24.000	.652	.064
	Roy's Largest Root	.069	.551[b]	3.000	24.000	.652	.064
TASK * SEX * GROUP	Pillai's Trace	.148	1.392[b]	3.000	24.000	.269	.148
	Wilks' Lambda	.852	1.392[b]	3.000	24.000	.269	.148
	Hotelling's Trace	.174	1.392[b]	3.000	24.000	.269	.148
	Roy's Largest Root	.174	1.392[b]	3.000	24.000	.269	.148
SITE	Pillai's Trace	.957	176.525[b]	3.000	24.000	.000	.957
	Wilks' Lambda	.043	176.525[b]	3.000	24.000	.000	.957
	Hotelling's Trace	22.066	176.525[b]	3.000	24.000	.000	.957
	Roy's Largest Root	22.066	176.525[b]	3.000	24.000	.000	.957
SITE * SEX	Pillai's Trace	.015	.119[b]	3.000	24.000	.948	.015
	Wilks' Lambda	.985	.119[b]	3.000	24.000	.948	.015
	Hotelling's Trace	.015	.119[b]	3.000	24.000	.948	.015
	Roy's Largest Root	.015	.119[b]	3.000	24.000	.948	.015

Appendix P - Multivariate Tests for High Alpha[c]

Effect		Value	F	Hypothesis df	Error df	Sig.	Eta Squared
SITE * GROUP	Pillai's Trace	.119	1.082[b]	3.000	24.000	.376	.119
	Wilks' Lambda	.881	1.082[b]	3.000	24.000	.376	.119
	Hotelling's Trace	.135	1.082[b]	3.000	24.000	.376	.119
	Roy's Largest Root	.135	1.082[b]	3.000	24.000	.376	.119
SITE * SEX * GROUP	Pillai's Trace	.112	1.012[b]	3.000	24.000	.405	.112
	Wilks' Lambda	.888	1.012[b]	3.000	24.000	.405	.112
	Hotelling's Trace	.127	1.012[b]	3.000	24.000	.405	.112
	Roy's Largest Root	.127	1.012[b]	3.000	24.000	.405	.112
TASK * SITE	Pillai's Trace	.928	25.822[b]	9.000	18.000	.000	.928
	Wilks' Lambda	.072	25.822[b]	9.000	18.000	.000	.928
	Hotelling's Trace	12.911	25.822[b]	9.000	18.000	.000	.928
	Roy's Largest Root	12.911	25.822[b]	9.000	18.000	.000	.928
TASK * SITE * SEX	Pillai's Trace	.453	1.656[b]	9.000	18.000	.173	.453
	Wilks' Lambda	.547	1.656[b]	9.000	18.000	.173	.453
	Hotelling's Trace	.828	1.656[b]	9.000	18.000	.173	.453
	Roy's Largest Root	.828	1.656[b]	9.000	18.000	.173	.453
TASK * SITE * GROUP	Pillai's Trace	.271	.745[b]	9.000	18.000	.665	.271
	Wilks' Lambda	.729	.745[b]	9.000	18.000	.665	.271
	Hotelling's Trace	.373	.745[b]	9.000	18.000	.665	.271
	Roy's Largest Root	.373	.745[b]	9.000	18.000	.665	.271
TASK * SITE * SEX * GROUP	Pillai's Trace	.555	2.494[b]	9.000	18.000	.047	.555
	Wilks' Lambda	.445	2.494[b]	9.000	18.000	.047	.555
	Hotelling's Trace	1.247	2.494[b]	9.000	18.000	.047	.555
	Roy's Largest Root	1.247	2.494[b]	9.000	18.000	.047	.555

Appendix P - Multivariate Tests for High Alpha[c]

Effect		Noncent. Parameter	Observed Power[a]
TASK	Pillai's Trace	6.335	.472
	Wilks' Lambda	6.335	.472
	Hotelling's Trace	6.335	.472
	Roy's Largest Root	6.335	.472
TASK * SEX	Pillai's Trace	8.174	.586
	Wilks' Lambda	8.174	.586
	Hotelling's Trace	8.174	.586
	Roy's Largest Root	8.174	.586
TASK * GROUP	Pillai's Trace	1.652	.146
	Wilks' Lambda	1.652	.146
	Hotelling's Trace	1.652	.146
	Roy's Largest Root	1.652	.146
TASK * SEX * GROUP	Pillai's Trace	4.176	.322
	Wilks' Lambda	4.176	.322
	Hotelling's Trace	4.176	.322
	Roy's Largest Root	4.176	.322
SITE	Pillai's Trace	529.574	1.000
	Wilks' Lambda	529.574	1.000
	Hotelling's Trace	529.574	1.000
	Roy's Largest Root	529.574	1.000
SITE * SEX	Pillai's Trace	.358	.069
	Wilks' Lambda	.358	.069
	Hotelling's Trace	.358	.069
	Roy's Largest Root	.358	.069

Appendix P - Multivariate Tests for High Alpha[c]

Effect		Noncent. Parameter	Observed Power[a]
SITE * GROUP	Pillai's Trace	3.246	.255
	Wilks' Lambda	3.246	.255
	Hotelling's Trace	3.246	.255
	Roy's Largest Root	3.246	.255
SITE * SEX * GROUP	Pillai's Trace	3.036	.240
	Wilks' Lambda	3.036	.240
	Hotelling's Trace	3.036	.240
	Roy's Largest Root	3.036	.240
TASK * SITE	Pillai's Trace	232.397	1.000
	Wilks' Lambda	232.397	1.000
	Hotelling's Trace	232.397	1.000
	Roy's Largest Root	232.397	1.000
TASK * SITE * SEX	Pillai's Trace	14.904	.557
	Wilks' Lambda	14.904	.557
	Hotelling's Trace	14.904	.557
	Roy's Largest Root	14.904	.557
TASK * SITE * GROUP	Pillai's Trace	6.707	.253
	Wilks' Lambda	6.707	.253
	Hotelling's Trace	6.707	.253
	Roy's Largest Root	6.707	.253
TASK * SITE * SEX * GROUP	Pillai's Trace	22.447	.770
	Wilks' Lambda	22.447	.770
	Hotelling's Trace	22.447	.770
	Roy's Largest Root	22.447	.770

a. Computed using alpha = .05

b. Exact statistic

Appendix P - Multivariate Tests for High Alpha[c]

c.

Design: Intercept+SEX+GROUP+SEX * GROUP
Within Subjects Design: TASK+SITE+TASK*SITE

Appendix P continued Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	151.836	1	151.836	6277.926	.000	.996	6277.926	1.000
SEX	8.225E-02	1	8.225E-02	3.401	.077	.116	3.401	.427
GROUP	2.958E-02	1	2.958E-02	1.223	.279	.045	1.223	.187
SEX * GROUP	3.068E-02	1	3.068E-02	1.268	.270	.047	1.268	.192
Error	.629	26	2.419E-02					

a. Computed using alpha = .05

Appendix Q Multivariate Tests for Forward Digits in High Alpha[c]

Effect		Value	F
SITE	Pillai's Trace	.942	131.027[b]
	Wilks' Lambda	.058	131.027[b]
	Hotelling's Trace	16.378	131.027[b]
	Roy's Largest Root	16.378	131.027[b]
SITE * SEX	Pillai's Trace	.105	.934[b]
	Wilks' Lambda	.895	.934[b]
	Hotelling's Trace	.117	.934[b]
	Roy's Largest Root	.117	.934[b]
SITE * GROUP	Pillai's Trace	.089	.786[b]
	Wilks' Lambda	.911	.786[b]
	Hotelling's Trace	.098	.786[b]
	Roy's Largest Root	.098	.786[b]
SITE * SEX * GROUP	Pillai's Trace	.047	.396[b]
	Wilks' Lambda	.953	.396[b]
	Hotelling's Trace	.049	.396[b]
	Roy's Largest Root	.049	.396[b]

Appendix Q Multivariate Tests for Forward Digits in High Alpha[c]

Effect		Hypothesis df	Error df
SITE	Pillai's Trace	3.000	24.000
	Wilks' Lambda	3.000	24.000
	Hotelling's Trace	3.000	24.000
	Roy's Largest Root	3.000	24.000
SITE * SEX	Pillai's Trace	3.000	24.000
	Wilks' Lambda	3.000	24.000
	Hotelling's Trace	3.000	24.000
	Roy's Largest Root	3.000	24.000
SITE * GROUP	Pillai's Trace	3.000	24.000
	Wilks' Lambda	3.000	24.000
	Hotelling's Trace	3.000	24.000
	Roy's Largest Root	3.000	24.000
SITE * SEX * GROUP	Pillai's Trace	3.000	24.000
	Wilks' Lambda	3.000	24.000
	Hotelling's Trace	3.000	24.000
	Roy's Largest Root	3.000	24.000

Appendix Q Multivariate Tests for Forward Digits in High Alpha[c]

Effect		Sig.	Eta Squared
SITE	Pillai's Trace	.000	.942
	Wilks' Lambda	.000	.942
	Hotelling's Trace	.000	.942
	Roy's Largest Root	.000	.942
SITE * SEX	Pillai's Trace	.440	.105
	Wilks' Lambda	.440	.105
	Hotelling's Trace	.440	.105
	Roy's Largest Root	.440	.105
SITE * GROUP	Pillai's Trace	.514	.089
	Wilks' Lambda	.514	.089
	Hotelling's Trace	.514	.089
	Roy's Largest Root	.514	.089
SITE * SEX * GROUP	Pillai's Trace	.757	.047
	Wilks' Lambda	.757	.047
	Hotelling's Trace	.757	.047
	Roy's Largest Root	.757	.047

Appendix Q Multivariate Tests for Forward Digits in High Alpha[c]

Effect		Noncent. Parameter	Observed Power[a]
SITE	Pillai's Trace	393.080	1.000
	Wilks' Lambda	393.080	1.000
	Hotelling's Trace	393.080	1.000
	Roy's Largest Root	393.080	1.000
SITE * SEX	Pillai's Trace	2.801	.224
	Wilks' Lambda	2.801	.224
	Hotelling's Trace	2.801	.224
	Roy's Largest Root	2.801	.224
SITE * GROUP	Pillai's Trace	2.357	.193
	Wilks' Lambda	2.357	.193
	Hotelling's Trace	2.357	.193
	Roy's Largest Root	2.357	.193
SITE * SEX * GROUP	Pillai's Trace	1.187	.117
	Wilks' Lambda	1.187	.117
	Hotelling's Trace	1.187	.117
	Roy's Largest Root	1.187	.117

a. Computed using alpha = .05

b. Exact statistic

c.
Design: Intercept+SEX+GROUP+SEX * GROUP
Within Subjects Design: SITE

Appendix Q Continued Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	36.852	1	36.852	4707.983	.000
SEX	4.267E-04	1	4.267E-04	.055	.817
GROUP	1.026E-02	1	1.026E-02	1.311	.263
SEX * GROUP	3.459E-02	1	3.459E-02	4.419	.045
Error	.204	26	7.828E-03		

Appendix Q Continued Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	.995	4707.983	1.000
SEX	.002	.055	.056
GROUP	.048	1.311	.197
SEX * GROUP	.145	4.419	.526
Error			

a. Computed using alpha = .05

Appendix R Pairwise Comparisons for Forward Digits for High Alpha

Measure: MEASURE_1

(I) SITE	(J) SITE	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	-6.598E-03	.013	.997	-4.315E-02	2.995E-02
	3	-.188*	.019	.000	-.242	-.134
	4	-.344*	.020	.000	-.399	-.288
2	1	6.598E-03	.013	.997	-2.995E-02	4.315E-02
	3	-.181*	.015	.000	-.225	-.137
	4	-.337*	.017	.000	-.386	-.289
3	1	.188*	.019	.000	.134	.242
	2	.181*	.015	.000	.137	.225
	4	-.156*	.012	.000	-.189	-.123
4	1	.344*	.020	.000	.288	.399
	2	.337*	.017	.000	.289	.386
	3	.156*	.012	.000	.123	.189

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Sidak.

Appendix S(a) Pairwise Comparisons For Group For Forward Digits for High Alpha

Measure: MEASURE_1

sex	(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.[a]
female	congruent	incongruent	-1.550E-02	.022	.490
	incongruent	congruent	1.550E-02	.022	.490
male	congruent	incongruent	5.257E-02*	.024	.035
	incongruent	congruent	-5.257E-02*	.024	.035

Based on estimated marginal means

Appendix S(a) Pairwise Comparisons For Group For Forward Digits for High Alpha

Measure: MEASURE_1

sex	(I) group	(J) group	95% Confidence Interval for Difference[a]	
			Lower Bound	Upper Bound
female	congruent	incongruent	-6.096E-02	2.997E-02
	incongruent	congruent	-2.997E-02	6.096E-02
male	congruent	incongruent	3.963E-03	.101
	incongruent	congruent	-.101	-3.963E-03

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Sidak.

Appendix S(b) Univariate Tests for Group for Forward Digits for High Alpha

Measure: MEASURE_1

sex		Sum of Squares	df	Mean Square	F	Sig.
female	Contrast	9.605E-04	1	9.605E-04	.491	.490
	Error	5.088E-02	26	1.957E-03		
male	Contrast	9.671E-03	1	9.671E-03	4.942	.035
	Error	5.088E-02	26	1.957E-03		

Each F tests the simple effects of group within each level combination of the other effects shown. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

Appendix T Multivariate Tests for Forward Spatial for High Alpha[c]

Effect		Value	F
SITE	Pillai's Trace	.967	233.663[b]
	Wilks' Lambda	.033	233.663[b]
	Hotelling's Trace	29.208	233.663[b]
	Roy's Largest Root	29.208	233.663[b]
SITE * SEX	Pillai's Trace	.081	.707[b]
	Wilks' Lambda	.919	.707[b]
	Hotelling's Trace	.088	.707[b]
	Roy's Largest Root	.088	.707[b]
SITE * GROUP	Pillai's Trace	.131	1.205[b]
	Wilks' Lambda	.869	1.205[b]
	Hotelling's Trace	.151	1.205[b]
	Roy's Largest Root	.151	1.205[b]
SITE * SEX * GROUP	Pillai's Trace	.047	.392[b]
	Wilks' Lambda	.953	.392[b]
	Hotelling's Trace	.049	.392[b]
	Roy's Largest Root	.049	.392[b]

Appendix T Multivariate Tests for Forward Spatial for High Alpha[c]

Effect		Hypothesis df	Error df
SITE	Pillai's Trace	3.000	24.000
	Wilks' Lambda	3.000	24.000
	Hotelling's Trace	3.000	24.000
	Roy's Largest Root	3.000	24.000
SITE * SEX	Pillai's Trace	3.000	24.000
	Wilks' Lambda	3.000	24.000
	Hotelling's Trace	3.000	24.000
	Roy's Largest Root	3.000	24.000
SITE * GROUP	Pillai's Trace	3.000	24.000
	Wilks' Lambda	3.000	24.000
	Hotelling's Trace	3.000	24.000
	Roy's Largest Root	3.000	24.000
SITE * SEX * GROUP	Pillai's Trace	3.000	24.000
	Wilks' Lambda	3.000	24.000
	Hotelling's Trace	3.000	24.000
	Roy's Largest Root	3.000	24.000

Appendix T Multivariate Tests for Forward Spatial for High Alpha[c]

Effect		Sig.	Eta Squared
SITE	Pillai's Trace	.000	.967
	Wilks' Lambda	.000	.967
	Hotelling's Trace	.000	.967
	Roy's Largest Root	.000	.967
SITE * SEX	Pillai's Trace	.557	.081
	Wilks' Lambda	.557	.081
	Hotelling's Trace	.557	.081
	Roy's Largest Root	.557	.081
SITE * GROUP	Pillai's Trace	.329	.131
	Wilks' Lambda	.329	.131
	Hotelling's Trace	.329	.131
	Roy's Largest Root	.329	.131
SITE * SEX * GROUP	Pillai's Trace	.760	.047
	Wilks' Lambda	.760	.047
	Hotelling's Trace	.760	.047
	Roy's Largest Root	.760	.047

Appendix T Multivariate Tests for Forward Spatial for High Alpha[c]

Effect		Noncent. Parameter	Observed Power[a]
SITE	Pillai's Trace	700.990	1.000
	Wilks' Lambda	700.990	1.000
	Hotelling's Trace	700.990	1.000
	Roy's Largest Root	700.990	1.000
SITE * SEX	Pillai's Trace	2.122	.177
	Wilks' Lambda	2.122	.177
	Hotelling's Trace	2.122	.177
	Roy's Largest Root	2.122	.177
SITE * GROUP	Pillai's Trace	3.615	.282
	Wilks' Lambda	3.615	.282
	Hotelling's Trace	3.615	.282
	Roy's Largest Root	3.615	.282
SITE * SEX * GROUP	Pillai's Trace	1.176	.116
	Wilks' Lambda	1.176	.116
	Hotelling's Trace	1.176	.116
	Roy's Largest Root	1.176	.116

a. Computed using alpha = .05

b. Exact statistic

c.
Design: Intercept+SEX+GROUP+SEX * GROUP
Within Subjects Design: SITE

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	37.382	1	37.382	5226.960	.000
SEX	2.438E-02	1	2.438E-02	3.409	.076
GROUP	1.873E-03	1	1.873E-03	.262	.613
SEX * GROUP	3.142E-03	1	3.142E-03	.439	.513
Error	.186	26	7.152E-03		

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	.995	5226.960	1.000
SEX	.116	3.409	.428
GROUP	.010	.262	.078
SEX * GROUP	.017	.439	.098
Error			

a. Computed using alpha = .05

Appendix U Pairwise Comparisons for Forward Spatial for High Alpha

Measure: MEASURE_1

(I) SITE	(J) SITE	Mean Difference (I-J)	Std. Error	Sig.[a]
1	2	-2.879E-03	.012	1.000
	3	-.175*	.019	.000
	4	-.339*	.015	.000
2	1	2.879E-03	.012	1.000
	3	-.172*	.018	.000
	4	-.336*	.015	.000
3	1	.175*	.019	.000
	2	.172*	.018	.000
	4	-.164*	.011	.000
4	1	.339*	.015	.000
	2	.336*	.015	.000
	3	.164*	.011	.000

Based on estimated marginal means

Appendix U Pairwise Comparisons for Forward Spatial for High Alpha

Measure: MEASURE_1

(I) SITE	(J) SITE	95% Confidence Interval for Difference[a]	
		Lower Bound	Upper Bound
1	2	-3.753E-02	3.177E-02
	3	-.230	-.121
	4	-.382	-.296
2	1	-3.177E-02	3.753E-02
	3	-.223	-.121
	4	-.379	-.293
3	1	.121	.230
	2	.121	.223
	4	-.196	-.131
4	1	.296	.382
	2	.293	.379
	3	.131	.196

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Sidak.

Appendix V Multivariate Tests for Backward Digits for High Alpha[c]

Effect		Value	F
SITE	Pillai's Trace	.923	95.992[b]
	Wilks' Lambda	.077	95.992[b]
	Hotelling's Trace	11.999	95.992[b]
	Roy's Largest Root	11.999	95.992[b]
SITE * SEX	Pillai's Trace	.097	.858[b]
	Wilks' Lambda	.903	.858[b]
	Hotelling's Trace	.107	.858[b]
	Roy's Largest Root	.107	.858[b]
SITE * GROUP	Pillai's Trace	.096	.849[b]
	Wilks' Lambda	.904	.849[b]
	Hotelling's Trace	.106	.849[b]
	Roy's Largest Root	.106	.849[b]
SITE * SEX * GROUP	Pillai's Trace	.215	2.193[b]
	Wilks' Lambda	.785	2.193[b]
	Hotelling's Trace	.274	2.193[b]
	Roy's Largest Root	.274	2.193[b]

Appendix V Multivariate Tests for Backward Digits for High Alpha[c]

Effect		Hypothesis df	Error df
SITE	Pillai's Trace	3.000	24.000
	Wilks' Lambda	3.000	24.000
	Hotelling's Trace	3.000	24.000
	Roy's Largest Root	3.000	24.000
SITE * SEX	Pillai's Trace	3.000	24.000
	Wilks' Lambda	3.000	24.000
	Hotelling's Trace	3.000	24.000
	Roy's Largest Root	3.000	24.000
SITE * GROUP	Pillai's Trace	3.000	24.000
	Wilks' Lambda	3.000	24.000
	Hotelling's Trace	3.000	24.000
	Roy's Largest Root	3.000	24.000
SITE * SEX * GROUP	Pillai's Trace	3.000	24.000
	Wilks' Lambda	3.000	24.000
	Hotelling's Trace	3.000	24.000
	Roy's Largest Root	3.000	24.000

Appendix V Multivariate Tests for Backward Digits for High Alpha[c]

Effect		Sig.	Eta Squared
SITE	Pillai's Trace	.000	.923
	Wilks' Lambda	.000	.923
	Hotelling's Trace	.000	.923
	Roy's Largest	.000	.923
SITE * SEX	Pillai's Trace	.476	.097
	Wilks' Lambda	.476	.097
	Hotelling's Trace	.476	.097
	Roy's Largest	.476	.097
SITE * GROUP	Pillai's Trace	.481	.096
	Wilks' Lambda	.481	.096
	Hotelling's Trace	.481	.096
	Roy's Largest	.481	.096
SITE * SEX * GROUP	Pillai's Trace	.115	.215
	Wilks' Lambda	.115	.215
	Hotelling's Trace	.115	.215
	Roy's Largest	.115	.215

Appendix V Multivariate Tests for Backward Digits for High Alpha[c]

Effect		Noncent. Parameter	Observed Power[a]
SITE	Pillai's Trace	287.975	1.000
	Wilks' Lambda	287.975	1.000
	Hotelling's Trace	287.975	1.000
	Roy's Largest	287.975	1.000
SITE * SEX	Pillai's Trace	2.573	.208
	Wilks' Lambda	2.573	.208
	Hotelling's Trace	2.573	.208
	Roy's Largest	2.573	.208
SITE * GROUP	Pillai's Trace	2.548	.206
	Wilks' Lambda	2.548	.206
	Hotelling's Trace	2.548	.206
	Roy's Largest	2.548	.206
SITE * SEX * GROUP	Pillai's Trace	6.579	.488
	Wilks' Lambda	6.579	.488
	Hotelling's Trace	6.579	.488
	Roy's Largest	6.579	.488

a. Computed using alpha = .05

b. Exact statistic

c.

Design: Intercept+SEX+GROUP+SEX * GROUP
Within Subjects Design: SITE

Appendix V Continued Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	38.885	1	38.885	4975.980	.000
SEX	5.311E-02	1	5.311E-02	6.797	.015
GROUP	1.723E-02	1	1.723E-02	2.205	.150
SEX * GROUP	8.819E-03	1	8.819E-03	1.129	.298
Error	.203	26	7.815E-03		

Appendix V Continued Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	.995	4975.980	1.000
SEX	.207	6.797	.709
GROUP	.078	2.205	.299
SEX * GROUP	.042	1.129	.176
Error			

a. Computed using alpha = .05

Appendix W(a) Pairwise Comparisons for Sex Backward Digits forHigh Alpha

Measure: MEASURE_1

(I) sex	(J) sex	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
female	male	-4.217E-02*	.016	.015	-7.542E-02	-8.921E-03
male	female	4.217E-02*	.016	.015	8.921E-03	7.542E-02

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Sidak.

Appendix W(b) Univariate Tests for Backward Digits for High Alpha

Measure: MEASURE_1

	Sum of Squares	df	Mean Square	F	Sig.
Contrast	1.328E-02	1	1.328E-02	6.797	.015
Error	5.079E-02	26	1.954E-03		

The F tests the effect of sex. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

Appendix X Pairwise Comparisons for Backward Digits for High Alpha

Measure: MEASURE_1

(I) SITE	(J) SITE	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	-2.884E-02	.014	.271	-6.903E-02	1.134E-02
	3	-.199*	.019	.000	-.252	-.146
	4	-.345*	.021	.000	-.404	-.286
2	1	2.884E-02	.014	.271	-1.134E-02	6.903E-02
	3	-.170*	.018	.000	-.221	-.120
	4	-.316*	.020	.000	-.373	-.259
3	1	.199*	.019	.000	.146	.252
	2	.170*	.018	.000	.120	.221
	4	-.145*	.013	.000	-.182	-.109
4	1	.345*	.021	.000	.286	.404
	2	.316*	.020	.000	.259	.373
	3	.145*	.013	.000	.109	.182

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Sidak.

Appendix Y Multivariate Tests for Forward Spatial for High Alpha[c]

Effect		Value	F	Hypothesis df	Error df	Sig.	Eta Squared
SITE	Pillai's Trace	.956	172.144[b]	3.000	24.000	.000	.956
	Wilks' Lambda	.044	172.144[b]	3.000	24.000	.000	.956
	Hotelling's Trace	21.518	172.144[b]	3.000	24.000	.000	.956
	Roy's Largest Root	21.518	172.144[b]	3.000	24.000	.000	.956
SITE * SEX	Pillai's Trace	.019	.151[b]	3.000	24.000	.928	.019
	Wilks' Lambda	.981	.151[b]	3.000	24.000	.928	.019
	Hotelling's Trace	.019	.151[b]	3.000	24.000	.928	.019
	Roy's Largest Root	.019	.151[b]	3.000	24.000	.928	.019
SITE * GROUP	Pillai's Trace	.095	.843[b]	3.000	24.000	.484	.095
	Wilks' Lambda	.905	.843[b]	3.000	24.000	.484	.095
	Hotelling's Trace	.105	.843[b]	3.000	24.000	.484	.095
	Roy's Largest Root	.105	.843[b]	3.000	24.000	.484	.095
SITE * SEX * GROUP	Pillai's Trace	.028	.231[b]	3.000	24.000	.874	.028
	Wilks' Lambda	.972	.231[b]	3.000	24.000	.874	.028
	Hotelling's Trace	.029	.231[b]	3.000	24.000	.874	.028
	Roy's Largest Root	.029	.231[b]	3.000	24.000	.874	.028

Appendix Y Multivariate Tests for Forward Spatial for High Alpha[c]

Effect		Noncent. Parameter	Observed Power[a]
SITE	Pillai's Trace	516.433	1.000
	Wilks' Lambda	516.433	1.000
	Hotelling's Trace	516.433	1.000
	Roy's Largest Root	516.433	1.000
SITE * SEX	Pillai's Trace	.453	.074
	Wilks' Lambda	.453	.074
	Hotelling's Trace	.453	.074
	Roy's Largest Root	.453	.074
SITE * GROUP	Pillai's Trace	2.529	.205
	Wilks' Lambda	2.529	.205
	Hotelling's Trace	2.529	.205
	Roy's Largest Root	2.529	.205
SITE * SEX * GROUP	Pillai's Trace	.693	.087
	Wilks' Lambda	.693	.087
	Hotelling's Trace	.693	.087
	Roy's Largest Root	.693	.087

a. Computed using alpha = .05

b. Exact statistic

c.

Design: Intercept+SEX+GROUP+SEX * GROUP
Within Subjects Design: SITE

Appendix Y Continued Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	38.737	1	38.737	3292.101	.000	.992	3292.101	1.000
SEX	2.766E-02	1	2.766E-02	2.351	.137	.083	2.351	.315
GROUP	4.641E-03	1	4.641E-03	.394	.535	.015	.394	.093
SEX * GROUP	2.056E-04	1	2.056E-04	.017	.896	.001	.017	.052
Error	.306	26	1.177E-02					

a. Computed using alpha = .05

Appendix Z Pairwise Comparisons for Backward Spatial for High Alpha

Measure: MEASURE_1

(I) SITE	(J) SITE	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	-3.570E-02*	.012	.040	-7.028E-02	-1.114E-03
	3	-.204*	.019	.000	-.257	-.151
	4	-.347*	.016	.000	-.393	-.301
2	1	3.570E-02*	.012	.040	1.114E-03	7.028E-02
	3	-.168*	.014	.000	-.207	-.129
	4	-.311*	.014	.000	-.352	-.271
3	1	.204*	.019	.000	.151	.257
	2	.168*	.014	.000	.129	.207
	4	-.143*	.014	.000	-.183	-.104
4	1	.347*	.016	.000	.301	.393
	2	.311*	.014	.000	.271	.352
	3	.143*	.014	.000	.104	.183

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Sidak.

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